SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MAY 1916.

GENERAL PHYSICS.

506. *Electric Counter for Rating Free-swinging Pendulum.* **F. W. Ellis.** (Science, 43. pp. 854–856, March 10, 1916.)—A heavy pendulum, vibrating through small arcs, and unconnected with clockwork or escapement, possesses several advantages for recording time in graphic experiments. Its especial merit is that its consecutive swings are so perfectly isochronous that it can be employed for testing tuning-forks and other vibrating recorders. The chief obstacle in employing a free-swinging pendulum for graphic purposes is the difficulty of determining its rate. The methods of coincidence devised by physicists necessitate the use of a standard clock, and are somewhat complicated. The present paper describes a simple electric counter for recording the exact number of beats in the period tested. It utilises for this purpose a telegraphic sounder which is placed in circuit and is periodically opened and closed by the pendulum that is being tested. For testing a tuning-fork the record of the pendulum and the graph of the fork are taken simultaneously, side by side, on smoked paper round a drum. E. H. B.

507. *Effect of General Mechanical Stress on the Temperature of Transition of Two Phases, with a Discussion of Plasticity.* **P. W. Bridgman.** (Phys. Rev. 7. pp. 215–228, Feb., 1916.)—This note is to present a thermodynamic formula of considerable generality, and to discuss some of its special cases. The need for such a formula arose in connection with experiments upon the effect of high pressures on melting-points and polymorphic transitions [see Abs. 1474 (1915)], and the problem resolved itself into finding the effect on a transition- (or melting-) point, of unknown extra stresses not hydrostatic in nature. The problem has up to the present received very meagre attention, and the formulæ given by James Thomson and Gibbs are for the restricted case of a fluid in contact with an isotropic solid under elastic stress. The author now extends these formulæ to the most general crystalline solid with its 28 constants, comprising 21 elastic constants, 6 thermal expansion constants, and one specific heat. By a double application of the formula the still more general case may be treated of two phases initially in equilibrium under any stress system not hydrostatic. It is found that given a crystal under a specified state of internal stress, and with specified stresses across the surface of separation from another phase, then the shift of the transition-point is entirely determined by these elements alone (to quantities of the order concerned), and does not involve at all the orientation of the surface with respect to any of the elements of symmetry of the crystal. This result is important as affecting the uniqueness of transition- or melting-points determined experimentally. The fact that the melting-point of a solid at a free surface is always depressed by any stress system whatever, is suggestive and of considerable importance, and offers the possibility of a revised theory of plasticity. This latter receives considerable attention and becomes stated as follows : A solid subjected to any stress system whatever, either tension, compression, or shear, experiences a depression of the melting-point at the unstressed surface (or at a surface stressed by less than the average amount) and melting will take place at that surface if the stress is high enough. This statement is free from all hypothesis as to the nature of the contact between the surfaces of the grains. Under some conditions plastic flow is produced by an actual local melting, followed by regelation with equalisation of pressure on all the grains. This local melting takes place when any grain is subjected to more than its share of the stress, and so is subjected to a stress not hydrostatic. The author next proceeds to inquire of how wide application this contributory agent in plasticity is, but concludes that it does not seem to be largely effective in the majority of the cases in practice. For some substances an analogous effect, due to displacement of polymorphic transition-points, is of more importance. H. H. Ho.

508. *Einstein's Theory of Gravitation and General Relativity.* **M. Born.** (Phys. Zeits. 17. pp. 51–59, Feb. 15, 1916.)—A general discussion of Einstein's theory. It is considered as not impossible that it may be found that not the motions of the heavenly bodies only, but also the actions taking place in the electron, atom and molecule, are subject, down to their ultimate foundation, to Einstein's laws. L. H. W.

509. *Strength of the Thin-plate Beam, held at its Ends and subject to a uniformly Distributed Load.* **B. C. Laws.** (Phil. Mag. 31. pp. 348–357, April, 1916.)—Mathematical treatment.

510. *Trajectory of Projectiles shot off with a large Initial Velocity at Angles in the vicinity of 45°.* **M. de Sparre.** (Comptes Rendus, 162. pp. 33–36, Jan. 3, 1916.)—This paper is an extension of a previous investigation on the above subject [Abs. 806 (1915)], and deals with certain corrections to be applied. The method has been employed for calculating the trajectory of the huge German gun which shelled Dunkirk recently. Tables are given and results calculated both for diminution in air density and also when this is assumed to be constant. H. H. Ho.

511. *Diagram to Facilitate the Study of External Ballistics.* **W. E. Dalby.** (Roy. Soc., Proc. 92. pp. 329–337, April 1, 1916.)—This paper describes a semi-graphical method for the investigation of the motion of a projectile, or in general the motion in a resisting medium where the resistance is given as a function of the velocity which cannot be expressed by any simple algebraic form. The solution curves are derived by simple graphical processes from a primitive curve which represents the results of numerous experiments, reduced to give the resistance of a standard projectile, fired under standard conditions, as a function of the velocity. This latter curve is reproduced in

the paper, reduced and slightly less than half size. From the educational standpoint the method has the advantage that the essential scientific principles relating to the motion of a projectile can be taught rapidly, and without reference to the laborious methods of analysis by means of which the ballistic tables are derived from the experimental data. Numerous examples with diagrammatic illustrations are given. H. H. Ho.

512. *Discontinuous Fluid Motion past a Curved Boundary.* **H. Levy.** (Roy. Soc., Proc. 92. pp. 285–304, March 1, 1916.)—Although many writers have dealt with this problem, no simple method has yet been evolved as in the corresponding case of a plane barrier. In aeronautics recent developments have shown the practical necessity for an effective discussion of the case where the plane is cambered, and so the present author attempts to show how two-dimensional problems of the motion of a curved surface through a fluid, or the efflux of fluid through an orifice in a vessel of any shape, may be solved; how to find the form of the free stream-line; and how the components of resistance may be calculated from the solution obtained. To do this it is assumed that the fluid is of vanishingly small viscosity; that the motion is two-dimensional and steady; and that the surface in its motion gives rise to a free stream-line, along which the pressure, and therefore the velocity, is constant, extraneous forces such as gravity being neglected. The method employed is based upon that in which the surfaces are planes and where solution is obtained by a series of conformal transformations. H. H. Ho.

513. *Waves due to a Travelling Disturbance, with an Application to Waves in Superposed Fluids.* **H. Lamb.** (Phil. Mag. 31. pp. 386–398, April, 1916.)—The paper commences with a mathematical investigation of the wave system due to a travelling disturbance. The cases of gravity waves on water and capillary waves are quoted as illustrations. An application to waves in superposed fluids is made, and the bearing on the phenomenon of "dead-water" considered. The latter is observed in Norwegian fiords and other similar localities, where the sea is covered by a stratum of fresh water brought down by rivers, and consists in an abnormal resistance experienced by slowly sailing vessels, which disappears if the speed can be raised above a certain limit. H. H. Ho.

514. *Ripple Wave-motion.* **F. R. Watson and W. A. Shewhart.** (Phys. Rev. 7. pp. 226–228, Feb., 1916.)—This paper describes the development of a method by which ripples may be generated not only in steady patterns but also in patterns in which the waves apparently move very slowly. This allows of a leisurely examination of the various phenomena. The method also allows the convenient exhibition of the waves to a lecture audience.

Ripples are generated by puffs of air blown against the water surface in a glass-bottomed tank. The puffs are secured by cutting a tube conveying compressed air and inserting in the gap a disc with a circular row of equally spaced holes. When the disc is rotated, the current of air is periodically interrupted. The waves are made visible by the stroboscopic method. Light from an arc lamp is focused on the row of holes in the rotating disc, thus giving flashes isoperiodic with the puffs of air. By reflecting the light upward through the glass tank, a steady pattern of ripples is revealed. By using a second row of holes, which were less in number than those in the row already described, the flashes of light could be made to come a little slower than the puffs of air; the result being that the waves apparently move forward slowly. A set of six photographic reproductions of the ripples is given in the paper. E. H. B.

515. *Theory and Experiments relating to the Establishment of Turbulent Flow in Pipes and Channels.* **L. V. King.** (Phil. Mag. 31. pp. 322–338, April, 1916.)—The paper is divided into two parts. The first part deals in four sections with the mathematical theory of viscosity and its experimental verification. Section I contains an historical survey of the theoretical development of the subject, and, as the experimental justification of the accuracy with which the fundamental hypothesis is able to give an interpretation of reality rests on the comparison of a small number of simple experimental conditions of viscous flow with the theoretical solutions, some of the latter are considered in the next three sections. Section II deals with steady motion between parallel planes, and here the linear hot-wire anemometer was used for a detailed experimental study of gaseous viscosity, involving not only the variation of the total flow with pressure-gradient, lengths and breadths of channels, etc., but an actual examination of the gradients of velocities themselves. Section III treats the case of steady motion in a pipe of circular cross-section. Section IV considers shearing motion between parallel planes.

Part II deals in two sections with the stability of laminar flow in pipes and channels. The first section gives at some length an historical and critical survey of the theoretical development, following which comes a discussion of experimental results on the flow of viscous fluids. The paper concludes with a table of theoretical and experimental values of Reynolds' constant relating to the flow of fluids in channels and pipes: $K = DU\rho/\mu$, where D is the diam. of the tube, U the mean velocity of the fluid, ρ its density, and μ its coefficient of viscosity. H. H. Ho.

516. *Viscosity of Liquefied Gases.* III. *Aperiodic Rotational Motion of a Sphere in a Viscous Liquid.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 18. 6. pp. 1038–1045, 1916.)—In the author's previous work on the rotational motion of a sphere in a viscous liquid [Abs. 151, 152 (1916)] the motion was supposed to be aperiodic. It is now shown, both analytically and also practically by an experiment with glycerine, that when the liquid has an outside boundary the motion may be aperiodic. A solution is derived for this case. T. H. P.

517. *Plastic Flow of Clay-Water Suspensions.* **E. C. Bingham.** (Washington Acad. Sci., J. 6. pp. 177–179, April 4, 1916.)—Suspensions of clay in water of concentrations above the point at which the flow ceases to be viscous and becomes plastic (*i.e.* requiring a shearing force of a definite magnitude to produce a permanent deformation) were forced under known pressures through capillaries of different dimensions. It is found that the volume of flow can be represented by the formula $v = k(P - f)$, where P is the pressure employed and f is the "friction," *i.e.* the force required to start the flow. If $(P - f)$ be put in place of P in the ordinary Poiseuille formula for calculating the fluidity, this gives a means for calculating the "mobility" of plastic substances, analogous to the fluidity of viscous substances. The friction increases as a linear function of the concentration of solid present. It is independent of the length and diam. of the capillary and of the viscosity of the medium, but is affected by the presence of alkalies or acids in the medium. The mobility decreases rapidly as the concentration of the solid is increased, and is enormously sensitive to the presence of alkalies or acids, the mobility of a neutral clay suspension being increased 880 % by the addition of 0·1 % of K_2CO_3. J. W. T. W.

518. *Brownian Molecular Movement under the Action of External Forces and its Connection with the generalised Diffusion Equation.* **M. v. Smoluchowski.** (Ann. d. Physik, 48. 8. pp. 1103–1112, Feb. 1, 1916.)—In the present paper the problem of a certain generalisation of the formula for the Brownian molecular movement has been treated, the author having already dealt with a number of special cases in a previous investigation [see Acad. Cracovie, Bull., p. 418, 1913]. Whereas the theory already developed by Einstein, Langevin, and the author, only deals with the simplest cases of the Brownian movement, in which a particle is assumed to be subject to the irregular molecular impact of its surroundings but otherwise uninfluenced by external forces, the author now considers how the respective laws change for cases where the particles are acted upon by given external forces. The problem is of outstanding theoretical interest, in that the gradual transition from the stage of uncontrolled Brownian movement to that of macroscopic physics where irreversibility rules, follows with mathematical exactness. It also offers opportunity for direct experimental application, and this is pointed out in the paper. H. H. Ho.

519. *Liapounoff's Formula for Rotating Liquids.* **P. Humbert.** (Comptes Rendus, 162. pp. 41–43, Jan. 3, 1916.)—A simplification is suggested of the formula given by Liapounoff for the analysis of figures of equilibrium of a liquid mass in rotation. C. P. B.

520. *Constitution of the Surface Layers of Liquids.* **S. A. Shorter.** (Phil. Mag. 31. pp. 260–275, April, 1916.)—A mathematical paper in which the author seeks to develop the thermodynamical theory of the subject in an elementary manner. The formula obtained by the author is applied to various cases, namely: the interface between the immiscible liquids, two partially miscible liquids, liquid phase in contact with vapour phase (both components being volatile), and liquid phase in contact with vapour phase (only one component volatile). The assumption sometimes made that the surface-layers of a liquid are in a state of compression is not found to be justified by the author. A. F.

521. *Relation between Surface Tension and other Quantities.* **M. Katayama.** (Tôhoku Univ., Sci. Reports, 4. 5. pp. 373–391, 1916.)—In place of the density of the liquid, the author introduces into the Eötvös equation the difference between the densities of the liquid and the vapour, thus obtaining the expression, $\gamma[M/(D_l - D_g)]^{2/3} = a(T_k - T)$. This equation does not contradict the theory of corresponding states and agrees with the experimental results for benzene, chlorobenzene, carbon tetrachloride, ether, ethyl acetate, and acetic acid; even at temperatures near the critical point, the mean value of a is 2·04. When the liquid under consideration is associated, the temperature coefficient of its molecular surface energy may be greater or less than the normal value of the constant a, so that the degree of association cannot be determined in this way. Van der Waals' equation connecting the surface tension and temperature, together with the above modification of the Eötvös equation leads to the expression, $D_l - D_g = 3{\cdot}08(1 - \theta)^{0{\cdot}351} . D_k$, and the Eötvös constant, a, and that of van der Waals, K_1, are connected thus: $(K/a)^{3/2} = 4$. Further, the following relation between the temperature

coefficient of surface tension and temperature Centigrade is obtained: $1/\gamma_0 \,.\, d\gamma/dT = B(1-t/t_k)^{B-1}$, B having the value 1·234; this expression is approximately the same as that of Walden for ordinary temperatures. Total surface energy and molecular total surface energy are calculated from the equation of van der Waals, and the following simple relation between the total surface energy and the free surface energy found: $u/\gamma = (1+0{\cdot}234\theta)/(1-\theta)$, this equation being confirmed experimentally. T. H. P.

522. *Tropical Hurricane of September* 29, 1915, *in Louisiana.* **I. M. Cline.** (Monthly Weather Rev. 43. pp. 456–466, Sept., 1915.)—A detailed account of the meteorological conditions accompanying a hurricane which moved northwards over south-eastern Louisiana. A good network of observing stations exists in the neighbourhood, so that details of the storm can be determined with more accuracy than is usual in such cases. At New Orleans, which lay about 8 miles east of the track of the centre of the hurricane, the barometer fell rapidly from 29·54 in. at 7 a.m. on the morning of Sept. 29 to 28·11 in. at 5.50 p.m., a fall of 1·43 in. in just under 11 hours. Between 3.10 p.m. and 5.50 p.m. the fall was 0·90 in. The reading of 28·11 in. given above was probably not far from the minimum pressure at the centre of the storm. At the same station the max. wind velocity over a five minutes' interval was 86 miles/hr. from the SE., while 60 miles/hr. was exceeded for 2 hours. Over a period of 30 secs. an extreme of 130 miles/hr. was recorded. Higher winds were measured at Burrwood, 100 miles south of New Orleans, where a 5-minute mean of 124 and an extreme of 140 miles/hr. were recorded. The total precipitation along the centre track of the hurricane was over 8 in. This almost all fell before the arrival of the centre. Heavier falls were experienced to the east than to the west of the track. The hurricane was unusual in that little lightning accompanied its passage. The diameter of the comparatively calm area at the centre was about 8 miles, while the outside diam. (marked by the 29·5-in. isobar) might be placed at between 250 and 300 miles. The rate of travel was about 12 miles/hr. Notification of the presence of the storm in the eastern part of the Caribbean Sea was first issued on Sept. 23, and later effective warnings were sent out; by this means much loss of life was undoubtedly avoided. J. S. Di.

523. *Distribution of Moisture in the Atmosphere.* **W. R. Blair.** (Monthly Weather Rev. 43. pp. 312–318, July, 1915.)—The absolute amount of water-vapour in the upper layers of the atmosphere is small, but the ratio of the weight of water-vapour to dry air may be as great at 20 km. and above as it is near the surface. In consequence of the importance of the relative water-vapour content at high levels in the consideration of the transmission of radiation to and from the earth, and of its influence on atmospheric temperatures, it becomes necessary to measure the amount of water-vapour present at all altitudes. A table is given showing from observations made both in summer and winter that the ratio between the weight of water-vapour to weight of dry air has a minimum value at 10 to 15 km., and that above that level the ratio may become greater than at any lower level. The author considers that this fact tends to disprove the supposition that mixing between the troposphere and the stratosphere takes place by diffusion only. R. C.

524. *Rain-gauge Exposures.* **W. G. Reed.** (Monthly Weather Rev. 7. pp. 318–322, July, 1915.)—This is a study of the rainfall over the watershed of

Strawberry Creek, about one square mile in area. The results obtained are conflicting, and the main generalisation adduced is that some kind of shielding of the gauge is highly desirable, at least in wind-swept regions, if accurate results are to be obtained. R. C.

525. *Circulation and Temperature of the Atmosphere.* **W. H. Dines.** (Monthly Weather Rev. 43. pp. 551–556, Nov., 1915.)—The general circulation of the atmosphere, in spite of the recent progress of meteorological science, remains a puzzle. The circulation is no doubt due to the effects of unequal cooling and heating of the earth's surface. The main facts to be explained are the trade-winds, the high-pressure belts to the poleward of the trades, the strong westerly winds of temperate latitudes, and the low pressures to the poleward of these winds. The effect of the earth's rotation is known to turn a wind current to the right in the Northern Hemisphere, to the left in the Southern, so that winds usually blow more nearly along the isobars than down the barometric gradient. At a height of about 1500 ft., where the effect of ground friction is insensible, the air is found to blow very accurately along the isobars.

The cause of the trade-winds which is usually put forward seems sound enough, but when the same reasoning is applied to temperate latitudes it fails utterly to account for the westerly winds there. The reasoning is the following:—Heated air rises above equatorial regions, and cooler air passes from north and south along the ground to take its place. The effect of the earth's rotation is to deflect these north and south winds into the NE. and SE. trade-winds. The same reasoning would, however, apply with stronger force to temperate latitudes, and would explain NE. and SE. winds in those latitudes and not the westerly winds prevalent there. These strong west winds of temperate latitudes follow, however, from an application to the atmosphere of the principle of angular momentum about the earth's axis. According to this principle feeble NE. and SE. trade-winds and strong west winds in temperate latitudes form a possible wind-system, but so would westerly trade-winds and easterly winds in higher latitudes, and there seems no particular reason why the second system should not form a possible arrangement. Indeed it would explain the glaciation of Europe, but not of North America.

The permanent systems of high pressure are usually explained by the effect of colder and therefore denser air above them in comparison with the air in the neighbourhood. But this explanation breaks down in the case of the Azores high-pressure system. Moreover, measurements of temperature in the upper air show that above a travelling cyclone the air is colder than it is above a travelling anticyclone.

Temperature in the upper air is controlled chiefly by pressure, the relation being nearly adiabatic. In Europe the temperature of the air column, except near the ground, follows very closely the variation of pressure at 8 or 9 km. above the ground. R. C.

526. *Ground Rainbows.* **A. E. Heath.** (Nature, 97. pp. 5–6, March 2, 1916.)—Describes a coloured bow similar to a rainbow of about the intensity of a good secondary rainbow, which was seen on the ground of a cricket-field at about 11 a.m. on Oct. 14, 1915. The sun was immediately behind the observer, and the bow appeared on the ground starting from just in front of the observer's feet and stretching on either side in a sweeping curve away from the sun. The bow is explained as being due to sunlight refracted twice at the near surfaces and reflected once at the back surfaces of drops of water that had condensed on gossamer which covered the field. On this theory the angle between the directions of the incident and emergent rays is 42½°, and the bow is the section by the ground of the cone of which the semi-vertical angle is 42½°, and the axis is the line joining the observer's eye to the sun. The bow will therefore be a circle, an ellipse, a parabola, or a hyperbola according as the sun is in the zenith, at an elevation of 42° to 90°, of 42°, or of less than 42°, respectively. The elevation of the sun was about 28° at the time of observation, and the bow was proved to be a hyperbola by pegging out its outline on the ground. **C. T. Whitmell, C. G. Knott.** (Ibid. p. 84, March 9, 1916.) R. C.

527. *Solar Radiation Measurements at Santa Fe (N. Mexico) and Maxima at other Stations.* **H. H. Kimball.** (Monthly Weather Rev. 43. pp. 439–443, Sept., 1915.)—A special interest attaches to the Santa Fe measurements on account of the station lying at an altitude of 7000 ft. in an arid region, where the atmosphere is generally very clear. The readings were mostly taken in the mornings, owing to the nature of the site not allowing free exposure to the west. The instrument used was a Marvin spiral pyrheliometer and the observations covered the period Oct., 1912, to July, 1915. Discussion of the results shows that reduced to mean solar distance the max. noon radiation intensities on a normal surface at Santa Fe exhibit little annual variation, showing that the more transparent atmosphere of winter compensates for the greater air mass traversed by the rays. With the sun at zenith distance 60° the measurements average about 15 % higher throughout the year than the monthly means for Washington. They differ little, however, from those at Madison, Wis., in the winter and early spring, owing to the ground at the latter station at this time of year being covered with snow and the air being consequently free from dust. Temperature is also cold and vapour contents therefore low. When extreme values are considered instead of means the excess of the Santa Fe values over those of Washington is less marked. The logarithms of the radiation intensities for different solar zenith distances have been plotted for certain days of max. radiation intensity against the corresponding air masses. The resulting curves are almost linear, and have been produced to cut the base line given by *air mass* = 0. From these extrapolated values the solar constant is determined after the application of a correction for humidity. The average value obtained for several stations by this means is 1·97 gm. cals. per cm.^{2} per min., or slightly higher than the mean value given by Abbot. This may be due to uncertainties in the method of correction for relative humidity. J. S. Di.

528. *Storm-frequency Change in the United States.* **H. Arctowski.** (Monthly Weather Rev. 43. pp. 379–389, Aug., 1915.)—A general discussion of the movement of depressions over the United States. The years 1888–1913 are taken, and the number of storm tracks which crossed the 100th, 90th, and 80th meridians in each month counted on the maps published in the Monthly Weather Review. This method of determining the storm frequency is preferred by the author to counting the number of storms which were felt in each month at certain well-distributed stations. Taking a mean of the figures for the three meridians a pronounced annual variation is found with a maximum of 9·4 storms per month in Jan. and a minimum of 5·9 in June. The distribution of these storms with regard to latitude is worked out, and attempts are made to trace the causes of the changes which occur from time to time. J. S. Di.

529. *Remarkable Fall of Hail in Maryland.* **O. L. Fassig.** (Monthly Weather Rev. 43. pp. 446–448, Sept., 1915.)—Severe hailstorms occurred on the afternoon of June 22, 1915, along a line about 100 miles in length running NW. and SE. through Baltimore. The most destructive hail was confined to a narrow belt of country about 5 miles in width. The fall seems to have been associated with the passage of the trough of a V-shaped depression and the disturbance was of the line-squall type. Accurate determinations showed that many of the hailstones measured up to 3 or 4 in. across, and in one town panes of glass ¼ in. thick in the skylight of a building were broken.
J. S. Di.

530. *On the Distribution of Cyclonic Precipitation.* **T. Terada.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 382–384, Feb., 1916. Abstract.)—From a detailed investigation of the precipitation accompanying depressions in the neighbourhood of Japan the following generalisations were deduced :—(A) On the front, *i.e.* NE., side of a depression the precipitation is more frequent on the Pacific side of the islands than on the Japan Sea side. On the rear side the reverse is the case. (B) When the centre of a depression lies on the Japan Sea far from the land the lines of equal rainfall have a tendency to run parallel to the axial line of the islands. (C) With depressions lying over the sea not far from the coast the Pacific depression is associated with a more dense and extended precipitation area on land than the Japan Sea one. The distribution of cyclonic rainfall outlined in these generalisations can be explained by considering the following influences: (1) Planetary thermal influence, which consists in the action of the difference of temperature with latitude. (2) The influence of the thermal contrast between land and water. This is also dependent upon the dampness or otherwise of the land considered. (3) The effect of the forced ascending or descending air current brought about by the discontinuity of the horizontal flow of air at the boundary of two regions with different coefficients of friction.
J. S. Di.

531. *Solar Corpuscular Rays.* **K. Birkeland.** (Archives des Sciences, 41. pp. 22–37, Jan. 15, and pp. 109–124, Feb. 15, 1916.)—From the discussion of an extensive series of auroral observations Störmer has decided to regard the phenomena as due to positive corpuscles emitted from the sun, coming into action in the upper atmosphere of the earth. Birkeland considers that corpuscles are negative, and brings forward the evidence given by his extensive experiments on the discharges from a magnetised kathode in a special vacuum chamber.
C. P. B.

532. *Solar Activity and Atmospheric Optical Phenomena.* **J. Maurer.** (Meteorolog. Zeits. 32. pp. 515–517, Nov., 1915. Monthly Weather Rev. 43. pp. 545–546, Nov., 1915.)—Details of the suspected discharge of particles from the sun have been described by Lenard, chiefly with regard to their velocity, magnetic deflection, and absorbability in the terrestrial atmosphere. During the period June 13–16, 1915, of considerable solar activity, brownish haze coronas were noticed in the region of the sun. It is hoped in future to make observations of atmospheric polarisation simultaneously with the recording of the haze phenomenon.
C. P. B.

533. *Remarkable Internal Seiches in Lake Inawasiro.* **K. Honda.** (Tōhoku Univ., Sci. Reports, 4. 5. pp. 328–331, 1916.)—An investigation of the ordinary seiches in this lake was concluded three years ago, and two principal periods of oscillation found, namely, a fundamental and a binodal. On that occasion, an undulation having a long period of about 6 hours was occasionally observed, but was then attributed to the effect of wind blowing with some periodicity. Observations, however, in Lake Tasawa led to the conclusion [see Abs. 985 (1915)] that the long period is due to the internal seiches in the lake. The present investigation was therefore undertaken, since it was found that a lake once disturbed will give rise to an internal seiche. The results are as follows :—Two long periods were observed corresponding to the fundamental and binodal internal seiches in the lake. The undulations of the short periods from 1 to 2 hours are always superposed on the undulations of the longer periods. Though the amplitude of undulation on the free surface due to the internal seiches is very small in comparison with that of the undulation on the layer of the rapid fall of temperature, yet it is easily observable in the records of the limnimeter, and the latter instrument can be used if only the periods of internal seiches be required, instead of the more laborious method of measuring temperatures. Numerous charts illustrate the paper.

H. H. Ho.

534. *Search for Trans-Neptunian Planet.* **P. Lowell.** (Lowell Observatory, Mem. 1. No. 1. Observatory, No. 498, pp. 185–187, March, 1916. Abstract.)—The memoir is the collection of a lengthy series of computations dealing with the problem of inverse perturbations, with the immediate purpose of investigating any possible evidence for the existence of a planet beyond Neptune. Observations of Neptune do not as yet cover a sufficiently large arc to give reliable residuals, but they will afford valuable data after the lapse of another century.

Observations of Uranus date back to 1690, and are now available over 2·7 revolutions of the planet. Lowell finds that a notable diminution of the residuals can be produced on the assumption of an unknown planet, but the data at present available give two possible positions, separated by 180° in longitude. Provisional elements of the unknown orbit are given. C. P. B.

535. *Plane of the Solar Motion.* **S. Oppenheim.** (Astron. Nachr. No. 4830. Nature, 97. p. 109, March 30, 1916. Abstract.)—After the publication by Kobold of his memoir on the plane of a solar motion, Harzer showed that the method reduced to the solution of a cubic equation giving the axis of what is known as the momentum-ellipsoid. Oppenheim now finds a complete explanation of these axes by an analysis of the geocentric motions of the minor planets. One axis appears to be directed to the solar apex, a second to the pole of the plane of the solar motion, and the third to the ideal centre of the stellar orbital movements. C. P. B.

536. *Anomalous Dispersion and Fraunhofer Lines.* **W. H. Julius.** (Astrophys. J. 43. pp. 43–66, Jan., 1916.)—The object of the paper is to examine the arguments which have been advanced in opposition to the idea that irregular refraction and anomalous dispersion may be important factors in the production of solar and stellar phenomena. It is admitted that so far no clear evidence of mutual influence of Fraunhofer lines has yet been obtained from observations of radial motion in sun-spots, but it is claimed that the results of Albrecht's work on iron lines in the solar spectrum do show the phenomenon. C. P. B.

537. *Determination of Planetary and Cometary Orbits.* **A. Jönsson.** (Ark. f. Mat. Astron. och Fysik, Stockholm, 10. 31. pp. 1–32, 1915.)—A long analytical paper giving details of formulæ for computing orbits of planets or comets. C. P. B.

538. *Comet* 1915*e* (*Taylor*). **A. Berberich.** (Astron. Nachr. No. 4827. Nature, 97. p. 46, March 9, 1916. Abstract.)—Taking the orbit for this comet computed by J. Braae and J. V. Hansen, the author finds that Comet Taylor is possibly the object observed by Spittaler on Feb. 4, 1891, when searching for Winnecke's Comet. C. P. B.

539. *Spectra of Comets* 1913*f* (*Delavan*) *and* 1914*b* (*Zlatinsky*). **N. v. Konkoly.** (Astron. Nachr. No. 4833. Nature, 97. p. 89, March 23, 1916. Abstract.)—From visual observations of the spectra of these comets during 1914, it was seen that they were very similar. The sodium line was present, and also five hydrocarbon bands at λλ5595·4, 5435·0, 5166·3, 4883·8, and 4723·8. C. P. B.

540. *Silicon Lines in Spectra of B-type Stars.* **A. Fowler.** (Roy. Astron. Soc., M.N. 76. pp. 196–197, Jan., 1916.)—The lines of Si which appear when the metal is subjected to powerful condenser discharges from a transformer are characteristic of the B-type stars. This spectrum has been studied from λ2000 to λ7000, and several new lines have been found, some of great intensity. Of the new lines four are given in detail showing their presence in the spectrum of β Crucis, a typical B_1 star. [See Abs. 1680 (1914).] C. P. B.

541. *Change of Star Colour with Distance and Apparent Magnitude.* **P. J. Van Rhijn.** (Astrophys. J. 43. pp. 36–42, Jan., 1916. Contribution from the Mt. Wilson Solar Observatory, No. 110.)—An investigation is given of the question of a possible relation between the colour of the stars and their distances, apparent magnitude and spectral type being the same. It is concluded that the stars of the Yerkes Actinometry show that the distant stars are redder than the nearer ones. From the material at present available it is not possible to decide whether this is to be ascribed to loss of light in space or to an influence of absolute magnitude. C. P. B.

542. *New Variable Star and Nebula in Corona Australe.* **R. T. A. Innes.** (Union Observatory of S. Africa, Circ. No. 33. p. 260, Jan. 7, 1916.)—Until recently the only known case of a variable nebula was that of Hind's nebula near the variable star T Tauri. Variability has now been detected in the star —37° 8450 and also in the nebulous envelope surrounding it. The position of the object is for 1875, RA = 18h. 53m. 15s.; Decl = — 37° 2·8′. The magnitude is usually 8·7, but on 1915 Oct. 29 it was found to be 12·4, and on 1915 Nov. 24 it was 11·5.

Examination of the Franklin-Adams charts confirms the variability of R Coronæ Australe and the adjacent nebula, so we now have the interesting fact of three known variable nebulæ, each of which is attached to a variable star. It remains to be seen whether these objects prove to satisfy Kapteyn's suggestion that in the case of the Nova Persei nebula the variability of the nebulosity was due to reflected light from the varying star. C. P. B.

543. *Mean Distances and Luminosities of Stars of various Spectral Types.* **C. V. L. Charlier.** (Ark. f. Mat., Astron. och. Fysik, Stockholm, 10. 28.

pp. 1–17, 1915. Lund Observatory, Meddelande, No. 68.)—An analysis is given for determining the mean parallax of stars of different stellar type, and the relations between mean distance and luminosity of stars of given spectral type, chiefly in criticism of conclusions published by various investigators. C. P. B.

544. *Observations of Variable Stars.* **C. Hoffmeister.** (Astron. Nachr. No. 4827. Nature, 97. p. 46, March 9, 1916. Abstract.)—A list is given showing observations of Algol and other short-period variables, and a number of suspected variables, including 7 Ursæ Majoris, with a range of 0·3 mag. [See Abs. 175 (1916).] **G. Hornig.** (Astron. Nachr. No. 4828. Nature, 97. p. 46, March 9, 1916. Abstract.)—Maxima and minima of ϕ Persei are given for the period Nov., 1914, to April, 1915. The period is 18·1 days.

Observations are also given of the irregular variables 7 Arietis, 15 Trianguli, and 81 Orionis. C. P. B.

545. *Stellar Photometry and Radiation Law.* **C. V. L. Charlier.** (Ark. f. Mat., Astron. och. Fysik, Stockholm, 10. 27. pp. 1–20, 1915. Lund Observatory, Meddelande, No. 67. Nature, 97. p. 148, April 13, 1916. Abstract.)—In previous communications the author has shown that the radiating energy for different wave-lengths and temperatures may be represented, in the neighbourhood of the maximum energy, by a simple formula obtained by considering the radiation formula as a normal frequency function, and determining the parameters by the known radiation laws of Stephen and Wien. Somewhat excessive values of λ and T are considered, as the results lead to an interesting inference regarding new stars. One of the results of the analysis gives evidence of a maximum value of the energy function, taking place at a temperature which the author designates the *inversion-temperature,* and whose value is given by the relation $T = 12{,}900^\circ/\lambda$. It has always been difficult to explain the rapid decline of a new star on the hypothesis of the phenomenon being due to a collision between two stars, but the difficulty is in great part removed if it is supposed that the stars after collision reach a temperature above the inversion-temperature. After the max. luminosity, the max. intensity would pass further into the ultra-violet, and there is a certain amount of support for this view in the known sequence of spectrum alterations in a new star after its visual decline. A long analysis is given of the theoretical numbers of stars of different magnitudes which may be observed with different instruments. C. P. B.

546. *Orbit of VV Orionis.* **Z. Daniel.** (Allegheny Observatory, Publ. 3. No. 21. Nature, 97. p. 46, March 9, 1916. Abstract.)—This object is an eclipsing variable and spectroscopic binary situated within 1° of the star δ Orionis, in common with which it exhibits the interesting spectral peculiarity that the K (calcium) line does not show the velocity displacements shown by other lines in the spectra. The spectrum is of type B_2, with diffuse lines. The period is 1·4854 days, superposed on a longer one of 120 days. C. P. B.

547. *Dark Markings on the Sky.* **E. E. Barnard.** (Astrophys. J. 43. pp. 1–8, Jan., 1916.)—Photographs of the sky often show the existence of dark markings, comparable in size with the nebulæ, scattered here and there over the heavens, and especially prevalent in the region of the Milky Way. One of these, near α Cephei, is reproduced in conjunction with the irregular nebula in Cygnus to illustrate the suggestive similarity in appearance, and the question is raised whether these objects may be in reality dark nebulæ.

C. P. B.

LIGHT.

548. *Apparatus for Stereoscopic Astronomical Photography.* **J. C. Solà.** (Comptes Rendus, 162. pp. 39–41, Jan. 3, 1916.)—A small apparatus, called the stereo-goniometer, is described, for facilitating the measurement of stellar proper motions from photographs taken at intervals with the same camera. The pairs of photographs are mounted over apertures in metal rings furnished with rackwork adjustment, so that the positions of maximum stereoscopic effect can be quickly recorded. C. P. B.

549. *Chronophotograph for measuring Ultramicroscopic Particles in Liquids.* **G. Rebière.** (Bull. Soc. Chim. [IV] 17. and 18. pp. 155–163, March, 1915.)—When the displacement of a particle by Brownian movement within a certain time can be measured, and the viscosity and temperature of the medium are known, the radius of the particles (assumed spherical) can be calculated. A kinematograph for this purpose was described by Henri in 1908, but it had the disadvantages that the interval between the successive pictures could not accurately be determined, and that the films were not suitable for photographing coloured objects, and also altered their dimensions during development, etc. The apparatus of the author is a vertically-mounted chronophotograph on which 10 images can be projected by an ultramicroscope with a magnification of 200 diameters at intervals of 0·75 sec. The panchromatic plate is 21 cm. long and 30 mm. wide. The movements of the plate (vertically upwards) and of the shutter are controlled by an electromagnet and a metronome, the shutter being kept open when the carrier is at rest. The shadows of cross-wires serve as reference lines. Details are given of experiments with colloidal sulphur contained in a quartz trough in water at 20°, a Zeiss apochromatic objective and Wratten and Wainwright plates being used. The sulphur grains were of unequal sizes, the movements of the large particles being 1·915, and of the small particles $20{\cdot}68 \times 10^{-8}$; the deduced radii are 144·9 and $13{\cdot}4 \times 10^{-7}$. H. B.

550. *Microscopy of Metals by Polarised Light.* **H. Hanemann.** (Zeits. Anorg. Chem. 88. pp. 265–268, Aug. 6, 1914.)—The author and K. Endell had described [see Abs. 2020 (1914)] a large and a small apparatus for the microscopic study of metals by reflected polarised light (after Königsberger). The smaller apparatus proves preferable; but with their 3·75-mm. quartz plate the change of the violet tint was only observable in a completely darkened room; a differential method is hence used, and a Biot-Soleil plate introduced instead of the quartz plate. The results are given in a table: ferrite is isotropic in electrolytic iron, mild steel, pearlitic specimens, tungsten steels, etc.; cementite anisotropic; Fe-Si alloys contain one anisotropic and two isotropic constituents; both Ag_3Al and ZnSb alloys are anisotropic. Importance is attached to the real difference established between austenite (isotropic in steels) and martensite (anisotropic). H. B.

551. *Effect of Temperature on Concave Grating.* **R. T. Birge.** (Astrophys. J. 43. pp. 31–35, Jan., 1916.)—It is well understood that to get perfect definition with a concave grating the temperature and barometric pressure must be maintained constant during the exposure. In a previous paper [Abs. 656 (1914)] the author has shown that the important effect of changing temperature is the change in the width of the grating space; the dispersion is directly proportional to this width, and hence also the distance of all lines from the slit, so that on any one plate the shift of all lines is approximately the same. Grebe [Abs. 844 (1914)] concluded that variations of not more than 1 deg. C. are not injurious, but the present author points out that at λ5000 a change of 1 deg. C. will cause a shift of as much as 0·18 Å., which is far from being negligible. Attention is also called to another effect of *temperature-gradients* across the face of the grating.

In using the method of coincidences it is shown that there will always be a shift of coincidences in different orders with varying temperatures, depending on the dispersion of air. C. P. B.

552. *Effect of Temperature upon the Coefficient of Absorption of Certain Glasses.* **K. S. Gibson.** (Phys. Rev. 7. pp. 194–202, Feb., 1916.)—The effect of temperature upon the absorption spectra of various kinds of coloured glass has been investigated by Houstoun and by Gibbs. Their results show that in general the absorption increases with temperature, though in some instances, in certain parts of the spectrum, it decreases. In some specimens, upon heating, the absorption bands remained stationary, and in others were displaced towards the red. Usually there was a complete recovery on coming back to the original temperature. The present paper gives details of experiments with five specimens of glass of known composition between temperatures of —180° C. and 480° C. A Lummer-Brodhun spectrophotometer was used. The results are all recorded graphically. Perhaps the most interesting and important result of the investigation is the enormous increase in the coefficient of absorption in certain parts of the spectrum. In the red glass, for instance, at certain wave-lengths, *k* is increased at 480° C. by more than 50 times its value at —180° C., and what was nearly a transparent glass in the region of 0·66 μ became nearly opaque. In spite of these big changes, there was in all the specimens nearly a complete recovery after the heating; and after cooling no change at all was found in the room-temperature curves. The biggest changes occur on the edge of the general absorption region, and this results in some cases in a shift of the point of maximum percentage transmission. A. W.

553. *Variation of Reflecting-power with Wave-length for an Isotropic Body.* **K. Uller.** (Phys. Zeits. 17. pp. 9–18, Jan. 1, 1916.)—Mathematical; does not permit of a short abstract. A. B. W.

554. *Apparent Lateral Reaction between Identical Pencils of Light-waves crossing each other at a Small Angle.* **C. Barus.** (Science, 43. pp. 282–284, Feb. 25, 1916.)—The pencils of light-waves were obtained by allowing parallel light from a collimator to fall normally on a plane reflecting grating and then reflecting from two opaque mirrors diffracted beams at equal angles to the normal. These reflected beams, by rotating the mirrors, can be made to cross at any angle, and a plane transmission grating is arranged so that the rays cross in the glass plate of the grating. With parallel rays, white light, and a fine slit, the linear phenomena of reversed spectra were obtained as usual. On using homogeneous light and a wide slit superb interferometer fringes were obtained. In every instance these are parallel striations crossing the whole field uniformly. They may be made coarser or finer, or rotated at pleasure, but a given field never shows independent groups; *i.e* there is no second periodicity distinct from the first. In the case of crossed rays, however, a uniformly striated field is only incidental. There is always a second periodicity present, distinct from the first. Suppose the original or regular striations are vertical and that sodium light is used, then the typical pattern observed looks like a set of thick twisted cords, hung side by side and equidistant. It is often much more complicated. Experiment shows that the lines consist of individual parts, behaving similarly, but independently, as if they were a set of magnetic needles. The same results may be obtained with the single strand of the linear phenomenon and white light. Again, if the original regular fringes were horizontal and apparently uniform, and the figure is made of maximum coarseness, on slightly passing one slit image of the other, to different degrees, micrometrically, the fringes then become like nodules, half black and half brilliant, strung transversely like bean-shaped beads on parallel strings and hung vertically against a neutral (non-interfering) yellow background of sodium light. The phenomena observed are difficult to explain; the suggestion is made that homogeneous rays on crossing (in the present case in a medium of plate glass) may exert a lateral influence on each other, to the effect that identical rays emerging from the crossing are arranged in equidistant nodal planes. [See Abs. 71 (1915).] A. W.

555. *The Necessary Conditions for Brewster's Law to be Valid.* **K. Uller.** (Phys. Zeits. 17. pp. 13–14, Jan. 1, 1916.)—The author considers the case of a monochromatic, electromagnetic plane wave, which after traversing one medium is incident upon a second, and for the reflected wave he makes use of a necessary condition which he had deduced in an earlier paper [Abs. 1724 (1915)]. This condition is found to signify that only when special relationships hold between the wave constants of both media can certain polarisation effects take place. These special conditions are discussed in detail with reference to glass, sodium, potassium, zinc, silver, gold, mercury, nickel, copper, Wood's alloy, and selenium. H. H. Ho.

556. *Spectral Luminosity-curve Equation.* **E. F. Kingsbury.** (Phys. Rev. 7. pp. 161–168, Feb., 1916.)—The sensitivity curve of the eye is now fairly well defined, and the present paper gives a form of equation which fits it more closely than the forms hitherto employed. The new equation is an enlargement of the Goldhammer form [see Abs. 1722 (1905)] employing three terms instead of one, the final result obtained being $L_\lambda = 0{\cdot}999(R_1e^{1-R_1})^{200} + 0{\cdot}04(R_2e^{1-R_2})^{400} + 0{\cdot}095(R_3e^{1-R_3})^{1000}$, where $R_1 = 0{\cdot}556/\lambda$, $R_2 = 0{\cdot}465/\lambda$, and $R_3 = 0{\cdot}610/\lambda$. From this equation the luminous power emitted by a black body at various temperatures can be readily computed, and thus the radiant luminous efficiency of a black body is found to be 18·5 % at about 6500° K. The Crova wave-length (*i.e.* that wave-length whose radiant power varies with any change of temperature by the same fractional part that the total luminous power varies for that temperature-change) is found from this equation to have a value of 0·58 μ in the neighbourhood of 2000° K. This is in agreement with the experimental value found previously. J. W. T. W.

557. *Illumination from a Radiating Disc.* **P. D. Foote.** (Bureau of Standards, Bull. 12. pp. 583–586, 1916 [Sci. Papers No. 269].)—Calculates the following formula for the illumination due to a radiating circular disc of finite size, the point at which the illumination is required being on a surface parallel to the disc and at a perpendicular distance K from it. If i is the brightness of the disc and a its radius, while x is the distance of the illuminated point from the axis of symmetry, then the illumination—

$$E = \tfrac{1}{2}\pi i\left[1 - (x^2 + K^2 - a^2)/\left\{x^4 + 2(K^2 - a^2)x^2 + (K^2 + a^2)^2\right\}^{\frac{1}{2}}\right].$$

It is readily deduced as a special case that the illumination at a point on the axis of the disc ($x = 0$) is given by $E = \tfrac{1}{2}\pi i[2a^2/(K^2 + a^2)]$. Some typical results are exhibited graphically in the paper. J. W. T. W.

558. *Candle-power of the Black Body and the Mechanical Equivalent of Light.* **E. P. Hyde, F. E. Cady,** and **W. E. Forsythe.** (Frank. Inst., J. 181. pp. 420–421, March, 1916.)—The candle-power of a vacuum carbon-tube black body was measured for a temperature range from 1800° to 2600° K. by means of a comparison lamp set at an approximate colour-match and subsequently measured in terms of carbon-lamp standards. The results at the different temperatures are given in the table.

BRIGHTNESS OF A BLACK-BODY FURNACE AT VARIOUS TEMPERATURES.

Temperature.	Candles per mm.^{2}	Temperature.	Candles per mm.^{2}
1700° K.	0·058	2200° K.	1·46
1800	0·118	2300	2·48
1900	0·244	2400	3·82
2000	0·45	2500	6·0
2100	0·80	2600	8·8

The average results give a value of 760 lumens per watt for the mechanical equivalent of light in the wave-length of greatest visibility. J. W. T. W.

559. *Effect of Atmospheric Pressure on the Candle-power of Flames.* **E. B. Rosa, E. C. Crittenden,** and **A. H. Taylor.** (Am. Illum. Eng. Soc., Trans. 10. No. 9. pp. 848–867, Dec. 30, 1915.)—Describes experiments upon the effect of change of external pressure on the candle-power of gas flames and of the pentane and Hefner lamps. A full description is given of the apparatus and method employed and a theory of the effect of pressure changes is discussed in detail. Sections of the paper are devoted to the effect of water-vapour and of vitiation of the air. J. W. T. W.

560. *Magnetic Rotary Dispersion and Electronic Theory; Dispersional Periods.* **S. S. Richardson.** (Phil. Mag. 31. pp. 232–256, March, 1916.)—This paper opens with an extended mathematical treatment of the subject, and then the results obtained are tested in the cases of water, benzene, *m*-xylene, naphthalene bromide, and carbon disulphide.

The calculation of ultra-violet free periods from ordinary dispersion leads in general to a mean effective value only. New formulæ are obtained for benzene, *m*-xylene, and α-monobromnaphthalene.

The value obtained from magnetic rotary dispersion using the formula $\phi = k[\lambda^2/(\lambda^2 - \lambda_1^2)]^2$ is usually much shorter and often progressive. It contains no adjustable constants, showing that in the case of the liquids here examined Meyer's formula is inapplicable.

When the result is progressive a close approximation to the longest dispersional period in the ultra-violet can usually be obtained from $\phi = k_1[\lambda^2/(\lambda^2 - \lambda_1^2)]^2 + k_2$, and this would seem to arise from a much sharper differentiation in the effects of bands of decreasing wave-length in the magnetic case.

For benzene (and possibly *m*-xylene) the longest period is almost an exact submultiple of the period of one of the infra-red bands [see Baly, Abs. 1258 (1914)]. C. S. G

561. *Radiation Properties obtained from the Debye Model of a Hydrogen Molecule.* **M. Wolfke.** (Phys. Zeits. 17. pp. 71–72, March 15, 1916.)—Debye has previously calculated the dispersion of hydrogen by means of a model of the hydrogen molecule. In the present paper the author investigates further the radiation results deduced from the model, since experiments with canal rays have given rise to the viewpoint that molecules as well as atoms function as emission carriers. A description of the Debye model is given, and the result found that if an assumption of Bohr with respect to radiation be adopted, namely, that by the passage of two electrons free energy is evolved in the form of a monochromatic radiation, then an exact reproduction of the hydrogen series spectrum is obtained. H. H. Ho.

562. *Principal Series of Sodium.* **R. W. Wood** and **R. Fortrat.** (Astrophys. J. 43. pp. 73–80, Jan., 1916.)—In a previous paper [Abs. 821 (1909)] it has been shown that the principal series of sodium is much more complete in the absorption than in the emission spectrum. Forty-eight members of the series were observed by the absorption method, only seven having previously been observed. The present paper gives the results of a repetition of the work on the absorption spectrum made with the very powerful quartz spectrograph at Zurich. This instrument is designed for double transmission through a train of six large quartz 60° prisms and one 30° prism backed by mercury (the equivalent of 13 prisms). The results obtained are as follows:—The number of members of the series has been raised from 48 to 58, ten new lines at the head coming into view. Previous investigations have shown as doublets only the first three members of the series, namely, the D lines, and the ultra-violet lines at λ3302 and λ2853. Four more have been distinctly resolved, so that we have now the wavelengths of the components of the first seven doublets of the series. The wave-lengths of all the lines of the series have been determined to the third place of decimals with reference to the new secondary standards of Fabry and Buisson, and a table is given. The last 32 members cover a spectral range not wider than the distance between the D lines. The formula proposed by Ritz for the principal series is—

$$\nu = \mathrm{N}\left[\frac{1}{\mathrm{A}^2} - \frac{1}{\left(m + a - \frac{b}{m^2}\right)^2}\right],$$

where $\mathrm{A} = [1{\cdot}5 + a' + b'/(1{\cdot}5)^2]$, and the table of wave-lengths shows a remarkable agreement between the observed and calculated values.

A. W.

563. *Ultra-violet Spectrum of Krypton.* **E. P. Lewis.** (Astrophys. J. 43. pp. 67–72, Jan., 1916.)—The author has examined the spectrum of krypton up to λ2100, and compares his results with the earlier measurements of Baly [Abs. 74 (1904)]; these latter, however, do not extend into the ultra-violet beyond λ2418 Å.U. Measurements were made with a 15-ft. grating and a condensed spark. The addition of a small inductance to the condensed spark-gap circuit caused a marked change in the spectrum, many of the lines being suppressed. The persistent lines which survive self-induction appear to exhibit constant-frequency-difference relationships. At least four such differences (95, 180, 165, and 722) occur so frequently that, although there are discrepancies, a definite relationship must be presumed. C. S. G.

564. *Structure of Spectrum Line* λ4686. **E. J. Evans** and **C. Croxson.** (Nature, 97. pp. 56–57, March 16, 1916.)—Previous experiments have shown that the 4686 line can be obtained by passing a condenser discharge through pure helium [Abs. 551 (1915)], and it was concluded that the results supported Bohr's theory [Abs. 1980 (1913)], which ascribed the line to He. The present experiments on the structure of the line were commenced with the purpose of testing still further its chemical origin, and of obtaining results which would throw further light on the mechanism of emission of spectrum lines. The tube finally employed was actuated by direct current, keeping the drop of potential between the anode and kathode as low as possible. The cylindrical spectrum tube was made large, as fairly heavy currents were passed through the gas; one of the Al electrodes was concave and the other was a hollow cylinder. With the cylindrical electrode as kathode the light was almost completely confined to the space inside the cylinder, and it was very intense. With the conditions of pressure and voltage used, although the ordinary helium lines were strong, the 4686 line was comparatively faint, and long exposures were necessary. The line was found to be surprisingly sharp, and all the photographs, for which a 88-plate echelon was used, showed that the line was a close doublet, the components having almost equal intensity, and their distance apart was found to be 0·094 Å.U. It is interesting to note that the separation to be expected on Rydberg's theory is 0·067 Å.U. Sommerfeld has recently published a paper on the structure of spectrum lines, based on a remarkable generalisation of Bohr's theory. In complete agreement with Sommerfeld's theory, Paschen has found that the 4686 line consists of three components, each of which was accompanied by fainter satellites, and the two stronger components were separated by a distance one-fourth of that between the outer components. Since the appearance of Sommerfeld's paper Evans and Croxson have examined their photographs again, and near one of the higher orders of the doublet, but not completely separated from it, found a faint line. If this is a lower order of the third component its separation, measured from the doublet, is about 0·40 Å.U., and it is situated on the higher wave-length side, as is to be expected according to Sommerfeld's theory. A. W.

565. *Single-line Spectra of Magnesium and other Metals and their Ionising Potentials.* **J. C. McLennan.** (Roy. Soc., Proc. 92. pp. 305–312, March 1, 1916.)—Franck and Hertz [Abs. 1584 (1914)] have shown that when heated mercury-vapour is traversed by electrons possessing kinetic energy slightly above that acquired in a fall of potential of 4·9 volts the vapour is stimulated to the emission of the single spectral line $\lambda = 2536{\cdot}72$. McLennan and Henderson [Abs. 1408 (1915)] have also shown that Hg-vapour gives this single-line spectrum when bombarded by electrons possessing energy corresponding to any fall of potential within a range beginning at about 5 volts and extending to slightly over 10 volts. The corresponding range within which Zn and Cd yield single-line spectra is from about 4 to 18·6 volts. The single lines of which the spectra of these three metals consist are the first members of Paschen's combination series $\nu = 2, p_2 - m, s$ for the three metals. It has now been found that a single-line spectrum can be obtained with Mg-vapour if the electrons bombarding the vapour possess energy lying within a certain range, whose limits have not as yet been definitely determined, but which covers a portion at least of the ranges mentioned above. The apparatus and method were the same as in the previous experiments. With Mg the single-line spectrum consists of light of wave-length λ = 2852·22. It has also been shown that the absorption spectrum of Mg-vapour is exactly analogous to that of Hg, Zn, and Cd, consisting of two bands, one at λ = 2852·22 and the other at λ = 2078·86. The analogy with the absorption spectrum of Hg is closer still, for the mercury absorption band at λ = 2536·72 comes out with small vapour densities as two narrow bands of wave-lengths [Wood] λ = 2536 and λ = 2539. The Mg band at λ = 2852·22 has also been found to consist of two narrow sharply-defined bands very close together. The corresponding Zn and Cd bands have not as yet been resolved into analogous doublets. The ionising potentials have been deduced for the atoms of Mg, Hg, Zn, and Cd; they are respectively, from calculations based on the conclusions of Franck and Hertz, 4·28, 4·9, 3·96, and 3·74 volts. Considerations are also presented which show that if Bohr's theory affords an explanation of the origin of single-line spectra, then Franck and Hertz, and also Newman, must have placed a wrong interpretation on the results of their direct investigation of the ionising potentials for mercury atoms.

A. W.

566. *Rontgen-ray Spectra.* **A. W. Hull.** (Frank. Inst., J. 181. pp. 423–424, March, 1916.)—This is an account of an attempt to measure accurately the quality and intensity of X-rays from a Coolidge tube. In the case of a tungsten antikathode, it is observed that there is a very rapid decrease in the wave-length, and at the same time an increase in intensity for all wave-lengths, if the voltage is increased. A penetrating ray free from soft radiation can be obtained only by using a filter exhibiting selective absorption for the latter. Measurements of the spectrum at 70,000 volts with and without an Al filter of 8 mm. thickness, indicate that the intensity of the soft rays has been reduced much more than that of the penetrating rays, but there is still a good deal of the former left. By using thicker filters to reduce still further the intensity of the soft rays, the intensity of the penetrating rays would also be cut down to a small fraction of their initial intensity, but with a powerful tube, such as is in process of development, it is hoped that there may still be left sufficient rays for practical work. [See also Rutherford, Barnes, and Richardson, Abs. 1417 (1915).]

E. A. O.

567. *X-ray Spectrum of Tungsten.* **W. S. Gorton.** (Phys. Rev. 7. pp. 203–208, Feb., 1916.)—In the work on the X-ray spectra of the elements, tungsten has been used as frequently as any other element, with the possible exception of platinum, but results of various observers are not in good agreement. In evidence of this the work of de Broglie, Herweg, Moseley, W. H. Bragg, etc. [see Abs. 243, 244, 675, 877 (1914)], with this element is reviewed briefly. In the present investigation a Coolidge tube was used as the source of X-rays, and the tube was excited by a 10-kw. interrupterless generator. This machine consisted of a step-up transformer and a synchronously revolving switch which rectified the high-tension e.m.f.

The "stationary crystal" method was employed, rock-salt and calcite being the crystals selected for the experiments. Tables of wave-lengths of lines shown in photographic reproductions are given, and the values compared with those of other observers. It was found that the results agree well with those of de Broglie (*loc. cit.*) but are uniformly lower, by 1 to 2·8 %, than those of Barnes [Abs. 1420 (1915)]. The cause of these discrepancies is discussed.

A. B. W.

RADIO-ACTIVITY.

568. *Behaviour of Radio-elements in Precipitation Reactions.* II. **K. Fajans** and **F. Richter.** (Deutsch. Chem. Gesell., Ber. 48. pp. 700–716, April 24, 1915.)—The conclusion of the first paper (Ibid. 46. pp. 3486–3497, 1913) was that a radio-element is carried down together with a precipitate of an ordinary element, from an extremely diluted solution, if under the prevailing conditions the radio-element itself would be precipitated when present in sufficient concentration—which meant in most cases that the radio-element must form a sparely soluble salt with the precipitating anion. This qualitative rule is now quantitatively tested with respect to thorium B, the percentage of which present in the original solution and in the precipitate (filtered or separated by centrifugal action) was estimated from its radioactivity. The absolute amount of ThB ranged from 1 to 5×10^{-13} gm. in different experiments. There is an unmistakable parallelity between the completeness of the removal of the ThB and the solubility of the salt it forms with the precipitating anion. The sulphide, sulphate, and carbonate which have solubilities up to 0·05 millimol/litre are almost completely precipitated; the nitrate which is soluble to 1·5 millimol, is not precipitated to any noticeable extent; the iodide and chloride, of intermediate solubility, are partly precipitated; in the two extreme cases the results are reliable, in the intermediate cases much depends upon conditions. When barium is incompletely precipitated from ThB solutions as sulphate, the ThB is partly precipitated. As regards the solubility of the ordinary precipitate for salts with the same anion, the authors agree with Wojtaszewski: $MnCO_3$, and $BaCO_3$, being themselves hardly soluble, precipitate ThB almost quantitatively, the readily soluble $(NH_4)_2CO_3$ precipitated only a few per cent. of the ThB present. Further, the degree of precipitation will be the higher, the less soluble the compound of the radio-element with the kathion of the precipitate. Concerning the precipitation of radio-elements together with their isotopes, the formation of solid solutions is the decisive factor; when there is no chemical analogy (ThB and AgCl), the precipitation depends upon adsorption. Adsorption is understood in the sense of Bragg, extended by Haber and Paneth. According to Bragg, the particles of a crystal are held together by the forces of chemical affinity in such a way that each kathion is held by all the anions near it (not only by one anion), and *vice versa*, so that there is a division of valencies in a crystal. If that hold also for the surface layers, part of the valencies must project into free space (Haber), and adsorption will become important for the saturation of those valencies; Paneth considers that in this kinetic exchange between crystal and solvent (in the growth of crystal) the anions and kathions participate separately, not only the molecules. The authors discuss and adopt these views. H. B.

569. *Density of Lead from Radio-active Minerals.* **T. W. Richards** and **C. Wadsworth.** (Am. Chem. Soc., J. 38. pp. 221–227, Feb., 1916. Chem. News, 113. pp. 97–99, March 3, 1916.)—The density of ordinary lead (at. wt. 207·2) and of lead from Australian radio-active sources (at. wt. 206·3) was carefully determined in a pyknometer. The density of ordinary Pb reduced to the vacuum standard was found to be 11·337, and that of radio-active Pb 11·288. Continued fractionation produced no change in this low density, and it could not have been due to any irregularity in preparing the metal since the samples were all prepared in the same way. This difference in density is especially interesting, because it almost exactly parallels the difference in atomic weight. Thus the atomic volume of radio-active Pb is found to be almost exactly equal to that of ordinary Pb, the figures being each very nearly 18·28. L. H. W.

HEAT.

570. *Thermal Expansions of Solids.* **A. Müller.** (Phys. Zeits. 17. pp. 30–31, Feb. 1, 1916.)—It is here endeavoured to apply Debye's expression for the expansion of isotropic monatomic substances to those temperatures at which c_v is no longer essentially dependent on T. From certain data a constant a in Debye's expression can be calculated, and its numerical value can also be approximately derived. [See Abs. 268 (1913).] E. H. B.

571. *Expansions of Gold and Quartz to 520° by Fizeau's Method.* **A. Müller.** (Phys. Zeits. 17. pp. 29–30, Feb. 1, 1916.)—For gold it is found that between 0° to 520° the following expression holds good: $[(l - l_0)/l_0] \times 10^6 = 14{\cdot}157t + 0{\cdot}002150t^2$. For quartz parallel to the axis, the coefficients are as follows for the range 0° to 360°: $7{\cdot}067t + 0{\cdot}008362t^2$. Complicated expressions apply for higher ranges. [See Abs. 550 (1905).] E. H. B.

572. *A Physical Study of the Thermal Conductivity of Solids.* **A. H. Compton.** (Phys. Rev. 7. pp. 341–348, March, 1916.)—In order to avoid complications due to electrons, only non-metallic substances, especially crystals, in which the atoms are closely packed, are considered. It is shown that the average distance through which the energy of an atomic collision in a crystal is transmitted is inversely proportional to the temperature, and is many times the distance between the atoms. This result depends on the assumption that each atom in a crystal absorbs a small fraction of the energy of the thermal disturbance, and transmits the rest. In a crystal in which the atoms are arranged in lines parallel to the axis of conduction, if d is the distance between successive atoms (as given by X-ray measurements), ν the natural frequency of the atoms as determined by optical methods, n^2 the number of atoms per unit area of the plane perpendicular to the direction of conduction, R the gas constant for a single molecule, and α the fraction of the energy absorbed by each atom (being proportional to the square root of the absolute temperature), then the thermal conductivity, k, is given by $k = bn^2d\mathrm{R}\nu(2 - \alpha)/\alpha^2$, where b is a constant involving m_1 and m_2, the masses of the atoms in collision. It appears impossible to obtain a satisfactory formula on the quantum hypothesis, but with plausible assumptions the agglomeration hypothesis leads to such a formula. T. B.

573. *Interpretation of Cooling Curves.* **H. Hanemann.** (Zeits. Anorg. Chem. 90. pp. 67–80, Nov. 24, 1914.)—The author proposes geometrical methods for correcting the cooling curves of solid solutions based upon the amounts of heat liberated at different stages. It is always important to know whether the max. retardation indicates the beginning or the end of a crystallisation; the end is generally more distinct. These and other considerations are discussed with special regard to the δ-iron region of the iron-carbon system and to the In-Tl alloys. H. B.

574. *Recalculation of some Thermal Relations.* **W. Herz.** (Zeits. Anorg. Chem. 89. pp. 397–400, Nov. 5, 1914.)—The author shows that some assumed thermal relations hold only very approximately and within limited ranges

He has not made any new experiments, but takes the values of Landolt and Börnstein's tables. The product of the absolute melting-point of a metal and of its linear coefficient of expansion should be constant according to Bayley, Lémeray, and others. This holds roughly for some metals near their melting-point, viz. for Al, Hg, Cu, Pt, Ag, which give approximately the constant 0·28; Pb and Cd yield 0·18 or 0·19; Bi only 0·07; Sn 0·12, whilst the values for Fe, Ni, Pd (and for Na) lie between 0·025 and 0·081 at high temperatures, above 1700° or 870° (Na). The quotient: specific heat × absolute boiling-point ÷ atomic weight, shows simple relations within any periodic group if the specific heat be taken at ordinary temperature. At the boiling-point the quotient: molecular heat of volatilisation ÷ (molecular volume)$^{\frac{1}{3}}$, is fairly constant; but the relation: absolute boiling-point ÷ (density)$^{\frac{1}{3}}$ has not any constant value. H. B.

575. *Influence of Secondary Air on the Inner Cone of the Bunsen Flame.* **L. Ubbelohde** and **O. Dommer.** (J. für Gasbeleuchtung, 57. pp. 738–740, July 25, 1914. Chem. Zentralblatt, II. p. 1879, 1914.)—In order to study the decided influence of secondary combustion on the primary combustion taking place in the inner cone, the authors determine the velocity of ignition and the flame temperature of divided and undivided flames. With 70 % of CO the velocity is 30 % greater, and the temperature 20 % higher, in the undivided than in the divided flame. With a burner of 0·7 cm. width secondary combustion products are found in the inner cone, when the gas contains 50 % or less of CO, and the secondary combustion becomes much more pronounced as the supply of primary air is diminished. Velocity and temperature, as well as the composition of the intermediate gas, are strongly influenced by the forms of the flame and zones. A stoichiometric mixture does not yield a CO flame of the highest temperature. Yet the theoretical mixture is most suitable for attaining high temperatures, since with high primary air-content the flame volume is little increased by secondary products, and the somewhat stiff flame resists the access of secondary products. H. B.

576. *True Temperature Scale for Tungsten, and its Emissive Power at Incandescent Temperatures.* **A. G. Worthing.** (Frank. Inst., J. 181. pp. 417–418, March, 1916.)—Measurements were made of the internal and external brightness of an incandescent hollow cylindrical tungsten filament perforated with small holes and mounted in a large lamp bulb. The ratio of the brightness of the external surface to that of an adjacent hole, when suitably corrected, gave the emissive power for tungsten at the surface temperature. Black-body temperatures were obtained by comparing the observed brightness with that of a black body at the palladium point by means of Wien's radiation formula. The true temperature scale consists of the relation thus found between the black-body temperature of the filament surface and that of the adjacent hole, *i.e.* the true temperature of the filament. A linear relation was found between the emissive powers and the true temperatures for the region between 1200° K. and 3200° K. such that the emissive powers for the two limiting temperatures were respectively 0·467 and 0·406. If this linear relation continues up to the melting-point it follows that this occurs at 3680° K. Further verification with other filaments is being tried before the publication of the completed paper. J. W. T. W.

577. *Colour-temperature Scales for Tungsten and Carbon.* **E. P. Hyde, F. E. Cady,** and **W. E. Forsythe.** (Frank. Inst., J. 181. pp. 418–420, March, 1916.)—By the colour temperature of a solid body radiating by virtue of its temperature is meant the temperature of a black body at which its radiation matches in colour that of the solid body in question. In the present investigation the colour temperature of tungsten is accurately determined by comparison with an electrically heated carbon-tube furnace, and this colour-temperature scale is compared with the true temperature scale of tungsten as determined by Worthing [see preceding Abs.]. The relation is also determined between the colour temperature and the specific output in lumens per watt radiated by the tungsten filament. It is seen from the table that the colour-temperature scale is very much closer to the true temperature scale than the so-called black-body scale which has been generally used in the past.

TUNGSTEN LAMP.

Lumens/Watt.	Colour Temperature.	Black-body Temperature. ($\lambda = 0{\cdot}665\,\mu$.)	True Temperature.
1	1763° K.	1627° K.	1729° K.
2	1917	1753	1875
3	2025	1840	1976
4	2109	1909	2056
5	2179	1967	2125
6	2237	2017	2184
7	2290	2062	2238
8	2338	2102	2286
9	2383	2140	2332
10	2425	2174	2378

Untreated carbon has also been studied, though with less precision owing to the non-uniformity of filament temperature and variations in the radiating properties of different allotropic forms of carbon. J. W. T. W.

578. *The Characteristics of Tungsten Filaments as Functions of Temperature.* **I. Langmuir.** (Phys. Rev. 7. pp. 302–330, March, 1916.)—A more complete account of the work dealt with in Abs. 322 (1916).

579. *On the Theory of the Equations of State.* **M. v. Smoluchowski.** (Ann. d. Physik, 48. 8. pp. 1098–1102, Feb. 1, 1916.)—Under the above title Wagner has already published a communication [see Abs. 778 (1915)] the object of which was to prove that van der Waals, Boltzmann, Kuenen, and all other authors were in error when they explained the action of the molecular attractive forces by the introduction of an internal pressure a/v in their formulæ. The author believes that this severe contradiction is due to a misunderstanding, and that the accepted mode of regarding the question still holds good, so that while admitting the difficulties which Wagner has raised he attempts in the present paper to give a suitable explanation to Wagner's objections. H. H. Ho.

580. *The Radiation Law and the Luminous Yield from Metals at High Temperatures.* **T. Peczalski.** (Comptes Rendus, 162. pp. 294–296, Feb. 21, 1916.)—The paper is a mathematical investigation of the radiation law with application to the luminosity of metals at high temperatures. Experiments have been undertaken to confirm the theoretical results. For tantalum the radiation law is $E = \sigma T^{4\cdot 3}$, where E is the energy radiated, and T the temperature. Other examples are given and interesting deductions made.

H. H. Ho.

581. *Determination of the Constant of Total Radiation from a Black Body.* **W. W. Coblentz.** (Bureau of Standards, Bull. 12. pp. 553–582, 1916 [Sci. Papers, No. 262].)—This is a continuation of former papers [see Abs. 1079 (1915)], and consists of (1) an historical summary of the principal determinations up to the present of the value of the constant, σ, of total radiation; (2) a new determination of σ by a method in which accurate corrections are made for lack of "blackness" of the radiator, for losses by reflection, for variation of thickness of lampblack layer, and for atmospheric absorption. It is demonstrated that the presence of aqueous vapour in unmeasured quantity is fatal to a correct measurement. The method employed is that of a modified Ångström pyrheliometer, where the heat received radiometrically is compensated electrically. The temperature of the radiator is about 1050° C., and the final value of σ is $5{\cdot}75 \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$. The mean value obtained from the best of the researches alluded to in the first part of the paper, after corrections have been made as far as possible for the factors mentioned above, is $5{\cdot}7 \times 10^{-12}$. T. B.

582. *Energy Distribution in Normal Radiation Spectrum.* **L. Page.** (Phys. Rev. 7. pp. 229–240, Feb., 1916.)—Planck's radiation formula is here derived from the expressions given by classical dynamics and electrodynamics for the absorption and radiation of energy with the aid of the supplemental assumption that the motion of an absorbing and emitting linear oscillator of frequency ν is stable only when the energy of its oscillations is an integral multiple of $h\nu$. This assumption avoids the necessity of replacing the emission of energy demanded by the electrodynamic equations by an emission that is discontinuous in time and difficult, if not impossible, to reconcile with the phenomena of diffraction and interference.

The partition of energy among the different degrees of freedom in the ether has been investigated, and found to be the same as in material oscillators. E. H. B.

583. *A New Relation derived from Planck's Law.* **P. D. Foote.** (Bureau of Standards, Bull. 12. pp. 479–482, Feb., 1916. Phys. Rev. 7. pp. 224–225, Feb., 1916.)—Of the many possible relations which may be derived from the radiation law of Planck only a few have received any attention. The most important of these are the two displacement laws of Wien, namely: $\lambda_{\text{max.}}\theta = \text{const.}$, and $J_{\text{max.}}\theta^{-5} = \text{const.}$ Salpeter has defined a function of λ and θ as follows: $\eta(\lambda,\theta) = J_\lambda \Big/ \int_0^\infty J_\lambda d\lambda$, where J_λ is the intensity of radiation of absolute temperature θ, and wave-length λ as determined by Planck's law. The functions $\partial\eta/\partial\lambda = 0$ and $\partial\eta/\partial\theta = 0$ have roots, giving $\lambda_m\theta = \text{const.}$ identical with Wien's displacement law. Any number of displacement laws may be derived from the Planck equation, and the present paper concerns the relation that the product of the absolute temperature and the λ-coordinate of the centre of gravity of the spectral energy curve is a constant. H. H. Ho.

584. *The Equation of State for Gases and Liquids.* **F. H. MacDougall.** (Am. Chem. Soc., J. 38. pp. 528–555, March, 1916.)—The author approaches this subject from another point of view to that of van der Waals, in the hope of finding a solution to the limitations from which the ordinary equation of state suffers. From any two of the three quantities, critical temperature, critical pressure, and critical volume, the theory of van der Waals enables us

to calculate *a* and *b*. If from the values so obtained the third critical quantity be calculated, then the result is found to be at variance with the facts, *e.g.* theory requires that the critical density shall be 2·67 times that of an "ideal" gas under the same conditions of temperature and pressure, whereas in all cases hitherto investigated the ratio is much larger, usually about 3·7. Most of the previous modifications attempt to meet this case, but cannot raise the ratio above 3. The author states that the object of his paper is to study Dieterici's equation in detail and to apply it to a number of well-investigated substances, since in his opinion it possesses a sounder theoretical basis than that of van der Waals. It reproduces the behaviour of a gas, not only at low pressures, but also at the critical point, and even at much higher pressures. Although, perhaps, not so simple an expression as van der Waals', many of the deductions from it are characterised by great simplicity and elegance. It has the great advantage of reproducing the critical state accurately, and in the author's opinion should be adopted. In the present paper various methods are developed for calculating the values of *a* and *b* below, at, and above the critical temperature. A formula is deduced for calculating the pressure of saturated vapour from the densities of the liquid and vapour, while another has been obtained for calculating the latent heat of vaporisation from the densities of liquid and saturated vapour. Isopentane, carbon dioxide, and hydrogen have been studied in some detail. In the case of isopentane *a* decreases and *b* increases from 0° C. up to the critical temperature. The same is true of CO_2. Above the critical temperature, in the case of CO_2, *a* continues to decrease, while *b* remains fairly constant up to 200° C. In the case of hydrogen, *a* decreases from the critical temperature up to ordinary temperatures, while *b* does the same, from −183° C. at least. For the latter, the inversion temperature is calculated, and also the temperature at which it "obeys" Boyle's law for moderate pressures. The latter temperature was calculated to be −171·4° C. Combining the law of Cailletet and Mathias with a result obtained by Young for a number of substances, it is shown that the density of a substance at the absolute zero is four times the critical density. The author's conclusions with regard to the variation of *b* with temperature are shown to harmonise with some of the views of T. W. Richards in respect to the compressibility of atoms. H. H. Ho.

585. *Statistical-mechanical Basis of Thermodynamics.* **T. Wereide.** (Phys. Zeits. 17. pp. 62–68, March 15, 1916.)—Classical thermodynamics is grounded on the principle that any isolated physical system of energy u, volume v, pressure p, and temperature T, possesses a characteristic function, namely the entropy, which is defined by the equation $S = \int (du + p\,dv)/T$, where the differentials refer to changes in the neighbourhood of equilibrium. All measurable alterations in the system take place in such a way that the entropy increases, and when such changes cease the entropy is a maximum. The present paper shows how this principle can be obtained from statistical-mechanical considerations. Gibbs's method is followed with one deviation, viz. that while Gibbs considered the statical properties of a system in different states, and defined the probability for a special state as the fraction of the system which is in that state at any given instant, the present author takes only one system and employs Einstein's probability method. H. H. Ho.

586. *Entropy and Probability.* **O. Postma.** (K. Akad. Amsterdam, Proc. 18. 7. pp. 1048–1056, 1916.)—In the kinetic definition of the entropy it is necessary to determine a function S which (1) satisfies the equation

$dS = d\phi/T$ on transition from a state of equilibrium to a neighbouring one, and (2) increases in an isolated system which is not in equilibrium. The S that satisfies the second demand must then also satisfy the first in the particular case that there is equilibrium. Additional constants [for (1): independent of energy and volume; for (2): independent of distribution of place and velocity] had no influence according to this theory. In connection with the theory of quanta, however, these constants have come more into the foreground, especially in so far as they depend on the elementary region g of the extension in phase of the molecules and their number N. Of late, attention has also been drawn to other properties which the entropy-function should satisfy, and more particularly: (3) the entropy of a quantity of substance is equal to the sum of the entropies of its parts. Further, the dimension of the entropy has also become of more importance. Calculating the entropy of a perfect gas in equilibrium state by the aid of the definition $S = k \log P$ ($P =$ probability) and with the fulfilment of condition (3), then g must be proportional to N. Important objections have been adduced against this result by Lorentz. This result together with its objections were obviated by Tetrode, who divided the entropy expression by $\underline{|N}$. Lorentz has stated that there is no physical reason for this, and the purpose of the present article is to subject the existing difficulties to closer examination.

H. H. Ho.

587. *Entropy of Material Systems.* **T. Wereide.** (Phys. Zeits. 17. pp. 68–71, March 15, 1916.)—The author here deals with the entropies of several different systems—namely: a homogeneous solid body, a homogeneous fluid, a fluid solution, a solid solution, and a gaseous mixture. He utilises the method that the entropy of a physical system may be determined by decreasing it so much that the volume is rendered as small as possible. If Z_0 be the minimum volume of the state, then the entropy in this condition is $S_0 = k \log Z_0$; if the entropy-decrease be now added the absolute value is obtained. The entropy thus consists of two parts—a variable measurable part, and the constant minimum entropy. Only the variable portion is considered in the paper; and this again subdivides into two members, one of which is dependent only on the energy, and the other only on the volume. Each of these is subjected to suitable change in order to arrive at the desired result. The method is then applied to each of the above-mentioned cases. The paper concludes with the development of a general formula for the entropy of material systems.

H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

588. *Determination of Work Function when an Electron escapes from the Surface of a Hot Body.* **H. H. Lester.** (Phil. Mag. 31. pp. 197–221, March, 1916.)—The equation for the thermionic emission from a hot metal in a vacuum has been deduced by Richardson and others from theoretical considerations involving the assumption that the potential energies of an electron inside and outside of the surface are different, so that an escaping electron must do work against an equivalent adverse p.d. (ϕ volts). The work done by an escaping electron is represented in the well-known Richardson equation, $i = a\theta^{1/2}\epsilon^{-b/\theta}$, by the constant b. In order to justify completely the assumption involved in b, such a work function should be found to exist, and its magnitude should be identical with that of b.

In 1908 Richardson showed that the escape of electrons should involve a loss of thermal energy, due to the fact that energy is rendered latent by the p.d. at the surface, and that this loss ought to increase rapidly with the temperature. Wehnelt and Jentzsch (1909) announced the discovery of such a cooling effect, and attempted its measurement, but were troubled by thermionic currents. Cooke and Richardson found such an effect in 1913. In 1910 the same experimenters had announced the discovery of a converse heating effect and had published values for a series of metals. The value of ϕ was calculated from both the heating and the cooling effects, and was found to be of the expected order of magnitude.

The present paper contains a discussion of the above work on the heating effect, and presents an extension of the measurements of the cooling effect for carbon, Mo, Ta, and W. The following features are also discussed: (1) Identification of b with ϕ. (2) Relation of ϕ to contact potentials. (3) Effect of gases on ϕ. (4) Nature of surface films. (5) New method for determining the temperatures of hot filaments. E. H. B.

589. *A Revision of the Expression for the Electromagnetic Mass of an Electron.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 362–367, Jan., 1916.)—The author first gives the usual mode of determining the electromagnetic mass of an electron resulting in the expression $m_0 = 4/8U_0/C^2$, where U_0 is the electrostatic energy of the electron, and C the velocity of light *in vacuo.* Criticism then follows and a new expression is deduced, namely: $m_0 = \gamma m_0^2/8\pi C_\infty^2 a + e^2/8\pi C_\infty^2 a = E_0/C_\infty^2$, where the electron is regarded as a sphere of radius a, with its charge e and total mass m_0 distributed over the surface, γ being the gravitation constant, and C_∞ the velocity of light at infinity. H. H. Ho.

590. *Crushing of a Copper Tube by Lightning.* **W. J. Humphreys.** (Monthly Weather Rev. 43. pp. 396–398, Aug., 1915.)—Photographs are given of a copper lightning conductor that has been crushed along its length and fused at its upper portion. Assuming that the collapse of the tube is due to the "pinch effect" of the current, it is calculated that a pressure of 10^6 dynes/cm.^{2}, or approximately of one atmosphere, would be produced

with the tube of 16 mm. external, and 14·65 internal diam., with a current of 19,470 amps., the discharge being unidirectional. It has been estimated that the duration of a lightning discharge is of the order of 0·01 sec. Also, as the brazed joint of the tube was opened by the fusion of the solder and the copper showed indications of incipient fusion along its length, the final temperature is estimated as having been about 1050° C. From these figures, taking the specific heat of copper as 0·11, it is deduced that the current must have had an average value of about 90,000 amps. or a max. value of 100,000 amps. Using the figure for the pressure obtained above and the fact that the pressure is proportional to the square of the current, it appears that the crushing pressure must have amounted to 400 lbs. per sq. in. A. J. M.

591. *Mercury Droplets and Electronic Charge.* **A. Schidlof** and **A. Karpowicz.** (Archives des Sciences, 41. pp. 125–148, Feb., 1916.)—Describes experiments with mercury droplets to determine the electronic charge with special reference to the infra-electronic charges claimed by F. Ehrenhaft, whose results the present authors fail to confirm. E. H. B.

592. *Electromagnetic Wave Constants of an Isotropic Body.* **K. Uller.** (Phys. Zeits. 17. pp. 85–87, Feb. 1, 1916.)—A theoretical paper in which these constants for a number of substances are calculated by the reflections formulæ from the polarisation data by various experimenters. [See Abs. 1725 (1915).] E. H. B.

593. *Path of a small Permeable Body moving with Negligible Acceleration in a Bipolar Field.* **P. E. Belas** and **M. Hartog.** (Roy. Dublin Soc., Proc. 15. pp. 33–40, Feb., 1916.)—The present investigation originated in Hartog's researches upon the "Mechanism of Mitosis in the dividing cell." The similarity of the spindle form assumed by the achromatin fibres of a cell undergoing division with that of inductive dust, when scattered on a flat surface, or suspended in a liquid of lower permeability, between two poles of opposite sign, led to a theory that at a particular stage in its life-history the cell was the seat of a dual force, like electrostatic, centring on two bodies—the centrosomes—whose field was bounded by the cell wall. The chromosomes were to be considered as portions of matter more permeable (in the broad Kelvin sense) than the medium in which they moved and their orientations in the equatorial plane, discessions, and migration to the centrosomes were to be accounted for by the differential action about the two force centres on these and on the surrounding medium. The present paper contains further experimental evidence in support of this theory. For modelling the phenomena of mitosis by a bipolar magnetic field, the problem arose as to what would be the path of a small disc of very soft iron if floated in a viscid liquid between the poles of an electromagnet—the disc at no time acquiring observable acceleration. Beyond the general statement that a permeable body would always move so as to include the greatest number of lines of induction, there was no previous record that the actual trajectory had been investigated. Full experimental details of the experimental solution of this problem are given in the paper. The following points deserve attention :—

(1) The path of the body depends on its size. (2) The field in which it moves is not constant, but is the resultant of the earth's field and a parallel field, which varies in intensity. (3) The presence of the body modifies the geometrical configuration of the field. Numerous curves are given to

illustrate the results obtained. As the curves show the paths of one particular body moving in one particular resultant field, the more general problem remains to be investigated, but the results found were adequate for the approximate physical data demanded by the biological phenomena.

H. H. Ho.

594. *Capacity of Approximate Spheres and Cylinders.* **Rayleigh.** (Phil. Mag. 31. pp. 177–186, March, 1916.)—A mathematical paper in which the capacities of approximate spheres and cylinders are calculated; formulæ are obtained which include the squares of small quantities. A. W.

595. *On the Contact Electricity of Solid Dielectrics towards Conducting and Non-conducting Liquids.* **A. Coehn** and **J. Franken.** (Ann. d. Physik, 48. 8. pp. 1005–1033, Feb. 1, 1916.)—The fundamental principle with regard to the contact electricity of non-conductors is that materials of higher dielectric constants are positively charged by contact with those of lower. A good method for establishing this principle is offered by electric osmosis. Quantitatively the charge of the electric double layer on the contact surface of the dielectric, is found to be proportional to the difference of the dielectric constants of both bodies. A theoretical proof of this has been given by Lenard [see Abs. 1446 (1915)] based on his investigation of the structure of the surface layers of liquids. In this present work the changes are investigated which the charging of liquid dielectrics undergoes when a given content of an electrolyte is present. The influence exerted by the electrolyte depends on its nature and concentration, and this was traced up to the reversal in sign of the charge. A large series of acids, bases, and salts were investigated, and the reversible concentrations found. For theoretical purposes it appeared of special interest to discover the influence of electrolytes on charging phenomena, not only for investigation of the waterfall effect, but also for the case of contact of liquids with solid non-conductors. The experiments were in most cases prejudiced by the fact that at high electrolyte concentrations, the special electrolytic phenomena together with decomposition products masked the results. Very full experimental details are given. For measuring the charging of solid dielectrics with respect to good-conducting solutions, without disturbance by electrolytic effects, an electrostatic method was adopted. The apparatus was designed to give automatically a continuous uniform contact with the fluids to be investigated. For charging both materials the apparatus rendered good reproducible values, and the charge of the solid dielectric increasing to a constant final value could be established by an automatic photographic registration. The influence of the electrolyte on the charging of the solid dielectric corresponds qualitatively to the like influence in the waterfall effect. The requisite quantities of electrolyte for the reduction of the charge are, however, much larger in this case. A reversal of the charge-sign by neutral salts is therefore only to be attained in such cases where the solubility of the neutral salt is sufficiently great. The superiority of the $\overset{+}{H}$ ions in their ability to reduce the charge is—as earlier in the waterfall effect—also here to hand, so that in all cases with acids a reversal may be obtained. The special case of the $\overset{+}{H}$ ion shows itself also in that a distinct temperature coefficient is manifested in the direction that increase of temperature acts like an increase in concentration. The temperature dependence of neutral salts and alkalies is either not in evidence or lies within experimental error. Dissolved nonelectrolytes are in dilute solutions, as in the waterfall effect, without influence on the charging. Should a wetting of the solid dielectric by a liquid take place, then there occurs no charging. Experiments with very viscous solutions appear especially suitable for giving further information on the mechanism of the charge phenomena investigated. H. H. Ho.

DISCHARGE AND OSCILLATIONS.

596. *Electric Deposits in Flames; Faraday's Law.* **B. Thieme.** (Zeits. Phys. Chem. 89. pp. 693–727, May 26, 1915.)—A continuation of former experiments [Abs. 540 (1912)] made with electrodes (wires or plates) in flames, generally luminous coal-gas flames, about 6 cm. high burning on tubes of 2 mm. diam., with battery and dynamo currents (0·2 to 455 volts) and also with other electric apparatus. The author first discusses the sources of error: the flame is cooled by the insertion of the electrodes (by 200° sometimes near electrodes), so that there is a purely thermal deposition of soot in addition to the electric deposition; the fine carbon particles are carried away by the draught; ordinary dynamo currents are not strictly continuous, so that some soot is deposited on the anode also. Fresh quite bright electrodes always give poor deposits. From the small current flowing through a flame at 455 volts the resistance of the flame would appear to be 182 megohms. The greater the current intensity, the more the shape of the flame is changed, and the flame broadens out along the kathode; that is, when the kathode is a wire held horizontally in the flame, the flame widens out above that wire, in the upper or the lower part of the flame, where the kathode is held. When the kathode is alone in the flame, the flame is lengthened; when the anode, the flame is shortened. On reversing the current the small threads of carbon particles stretching from the kathode over to the anode drop off; with alternating currents the deposits form on both electrodes, but are always thicker on the cooler of the two electrodes. The threads oscillate with the frequency of the current, and are acted on by the magnetic field. When the flame is between the plates of a condenser, the carbon particles are first attracted, then repelled, and then rise like non-electric particles. When the frequency exceeds 900 per sec. (singing arc arrangement) carbon is no longer deposited, so that a time of at least 0·0006 sec. seems to be required by the electrodes to produce ionisation.

R. v. Traubenberg had confirmed Faraday's law for flames in 1912; the author tests this with iron electrodes, 20 mm. apart, and finds that carbon seems to be univalent at higher (flame) temperatures, having a higher valency at lower temperatures; the amount of carbon deposited at 120 to 450 volts and currents ranging from 0·0008 to 0·0048 amp. corresponded to a univalent carbon. Faraday's law also seemed to hold for Bunsen flames, fed with copper sulphate, with Pt electrodes supported by copper plates and currents at pressures up to 1800 volts. H. B.

597. *Relation between Photoelectric Current and Illumination.* **H. E. Ives, S. Dushman,** and **E. Karrer.** (Astrophys. J. 43. pp. 9–35, Jan., 1916.)—Experiments described in an earlier paper [Abs. 1888 (1914)] showed that the relationship between illumination and current in potassium photoelectric cells is not rectilinear, but is in general a complicated function of applied voltage, electrode distance and gas pressure. Subsequent investigation has resulted in the discovery of the cause of these complications, with the conditions necessary for producing the straight-line relation. The course of

the investigation is illustrated by numerous graphs showing the different photoelectric currents with varying voltage and illumination, and widely varying types of cell construction. The anomalous behaviour has been traced to the action of focusing effects caused by the accumulation of charges on the walls of the cells, and a type of cell has been devised which affords perfect control of the photoelectric action, thereby giving a considerable advance in sensibility which should facilitate the work of stellar photometry. The difficulty with regard to varying colour sensibility still remains as before. C. P. B.

598. *Photographs showing Relative Deflection of Positive and of Negative Ions as compared with that of the Electron.* **C. T. Knipp.** (Science, 43. pp. 393–394, March 17, 1916.) T. H.

599. *Kathode Measurements with Glow Current in Hydrogen.* **W. L. Cheney.** (Phys. Rev. 7. pp. 241–252, Feb., 1916.)—Skinner [see Abs. 1309, 1454 (1915)] has developed a theory of the kathode-fall in gases which suggests that with a plane kathode the "normal" current density should be proportional to the square of the gas pressure, provided the number of mean free paths of the electrons from the kathode to the point of minimum gradient in the negative glow is the same for all pressures. In measurements made with Al and steel kathodes in hydrogen, both of these conditions were found to exist. The purpose of this research is to repeat some of Skinner's measurements with Al and steel, and to extend the investigation to various other metals. The apparatus used is described in detail and the results obtained are given in tabular and graphical form. The "normal" current density at the kathode has been measured in hydrogen with Al, steel, Ni, Zn, and Pt as kathodes, and found in all cases to be proportional to the square of the gas pressure. The number of mean free paths of the electron from the kathode to the point of minimum gradient in the negative glow has been measured for these metals under the same conditions and found to be independent of the gas pressure. Potential curves in the gas between the kathode and the negative glow have been obtained at "normal" current density with the above metals as kathodes. The potentials plotted against the number of mean free paths of the electron from the kathode lie, for all pressures, practically on the same curve. From these potential measurements, the mobility of the positive ions has been calculated and consistent values obtained for all metals except Pt, where the mobility is somewhat low, probably arising from the presence of metal vapour. The potential curves have been theoretically extended to the kathode, and the fall between the kathode and the gas was obtained therefrom. The ratio of the electron current from the kathode to the total current has been calculated for the various metals. A. E. G.

600. *Kathode Measurements with Glow Current in Oxygen and Nitrogen.* **W. Neuswanger.** (Phys. Rev. 7. pp. 253–268, Feb., 1916.)—Skinner recently developed a theory of the kathode-fall in gases and gave a general relation between the fall, the current density, mean free path of the electron and the distance from the kathode to the point of minimum potential gradient in the negative glow [Abs. 1309, 1454 (1915)]. Experiments with hydrogen supported the theory. In the present paper the author investigates the kathode-fall in oxygen and nitrogen and finds that, as for hydrogen, all pressures giving the normal kathode-fall have the

same number of mean free paths to the point of minimum potential gradient in the negative glow and have a normal current density proportional to the square of the gas pressure. With normal current density the kathode-fall is a minimum, and as the current is increased the fall of potential immediately at the kathode increases, while the fall through the gas to the negative glow decreases. This decrease is attributed to the larger proportion of the total current carried by the electrons, which reduces the distance from the kathode to where the negative charge in the gas equals the positive.

The p.d. between the kathode and any point at a definite number of mean free paths from it is found to be a function of the ratio of current density to square of gas pressure. T. H.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

601. *Edge Effect of Plate Condensers.* **C. J. Watson.** (Electrician, 76. p. 883, March 24, 1916.)—A square of lead-foil, of 24 cm. side, was pasted on plate glass and placed opposite another, which exceeded it by 0·6 cm. all round; the two electrodes were kept apart by bits of glass 0·29 cm. thick. Another similar condenser was made having the smaller plate of the same area, but in an oblong form, being 85 cm. long. The capacity of the second condenser was about 8 % greater than that of the first. To increase the effect another square plate, similar to that of the first condenser, was cut into 4 strips and fixed on the glass 2·5 cm. apart; they were joined by narrow strips and the area was adjusted to that of the original square. The capacity was found to be increased by 30 %. From these and other experiments the author is convinced that with plates 1 ft. square and $\frac{1}{8}$ in. apart the capacity is at least 20 % more than that calculated from the formula $C = A/4\pi d$.

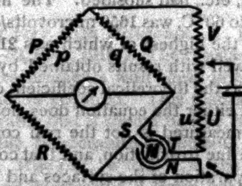
G. E. Bairsto. (Ibid. 77. p. 28, April 7, 1916.)—Bairsto states that if Kirchhoff's formula is applied to a circular plate of over 1 sq. ft. placed at a distance of $\frac{1}{8}$ in. from the second plate, the capacity is increased by 4·8 %. Since square plates will give a greater effect, and there may be effects due to surrounding bodies, Bairsto considers that errors of 20 % may easily arise in the case considered. I. W.

602. *Tests of Thermoelectric Formulæ based on Bismuth and Bismuth-Tin Alloys.* **A. E. Caswell.** (Phys. Rev. 7. pp. 269–277, Feb., 1916.)—Barker and Caswell have described an apparatus to measure the Peltier-effect directly [Abs. 892 (1912)]. Modifications have now been made in this to admit of direct determinations of the Kelvin-effect and the thermoelectric force. This apparatus is to be described in a future paper on measurements of the Kelvin-effect. In the present paper the author gives results of experiments on the Peltier-effect and the thermoelectric force for bismuth and certain alloys of Bi and Sn containing less than 10 % Sn. Measurements of the thermo-e.m.f. serve as a check on the direct measurements of the Peltier e.m.f. if we assume Kelvin's equation connecting thermoelectric power (Q) and Peltier e.m.f. (P), viz. $P = QT$. The results obtained are discussed from the point of view of the electron theory. According to Drude, the Peltier e.m.f. at absolute temperature T is $[2RT \log(n_1/n_2)]/e$, where R is the gas constant of a gm.-molecule, e the charge carried by the H-ion in electrolysis and n_1, n_2 are the numbers of electrons per unit volume in the two metals which take part in the phenomenon. The formulæ of J. J.

Thomson and O. W. Richardson differ from Drude's in that they do not contain the factor 2. The author deduces the value of n_1/n_2 from his data on Peltier-effect and thermoelectric power and concludes that the Kelvin equation is satisfied. He then assumes that in these alloys, containing a small percentage of Sn, the mean free path of an electron remains sensibly the same; also the electrons concerned in thermoelectric phenomena are identical with those taking part in electrical and thermal conduction. Drude's theory then leads to the result that $\sigma_1/\sigma_2 = n_1/n_2$ and $k_1/k_2 = n_1/n_2$, where σ denotes specific electrical resistance and k thermal conductivity. Using Schulze's results for the resistance and thermal conductivity of Bi and Bi-Sn alloys he deduces values for n_1/n_2. These values agree better with those calculated from the thermoelectric data on the Drude theory than with those using the formula of J. J. Thomson. With the Thomson formula if we assume the electrons in the thermoelectric case identical with those in conduction the mean free path in one of these alloys would have to be 1·8 times that in the pure metal. On the other hand, if equality of mean free path be assumed $(n_1/n_2)^2 = N_1/N_2$, where n denotes the electrons per unit volume concerned in conduction and N those in thermo-electricity.

L. L.

603. *Comparison of Self and Mutual Inductance.* **C. H. Lees.** (Phys. Soc., Proc. 28. pp. 89–98; Disc., 98. Feb. 15, 1916. Electrician, 77. pp. 123–124, April 28, 1916. Abstract.)—When a resistance bridge for the comparison of the mutual inductance between two coils with the self-inductance of one of them has been set up and balanced for steady currents, it is very often found that no inductive balance can be obtained with the form of bridge adopted, or with the values of the resistances of the ratio arms which have been used. Another pair of values for the resistances of the ratio arms or another form of bridge has to be substituted, balanced for steady currents, and an induction balance again attempted. To abolish this waste of time the bridge arrangement shown in the Fig. is recommended. It is shown that the self-inductance L of a coil of resistance S may be compared with the mutual inductance M between the coil and another by making the first coil one arm of a bridge, PQRS, of which the second coil and a resistance U + V in series form one diagonal, the galvanometer forming the other. The cell is connected through a key to the point of contact of U and V. When the steady balance has been obtained U or V can be varied so as to get an induction balance for any value of L/M without P, Q, R, or S having to be changed. Then $L/M = -[Q + S + (1 + Q/P)V]/(T + U)$.



F. E. S.

604. *Study of the Volta-effect by the Aid of Induced Radio-activity: Discovery of Two New Effects.* **E. Sarasin** and **T. Tommasina.** (Comptes Rendus, 162. pp. 291–294, Feb. 21, 1916.)—The present paper is a further study of the Volta-effect by the aid of reduced radio-activity. Previous results have already been presented. Two new effects have now been elucidated which together with preceding data have enabled the authors to construct a very sensitive apparatus whereby the direct study of electrodes separated by air or in contact may be effected, and a comparison made to an analogous effect due to a simple pile element. The authors believe their apparatus to be capable of affording a correct theory of the pile, and to settle the question of whether its action is chemical, or one of specific potential, or a combination of both. A description of the apparatus is given and further investigation promised. H. H. Ho.

605. *Temperature Coefficient of Contact Potential.* **K. T. Compton.** (Phys. Rev. 7. pp. 209–214, Feb., 1916.)—From a consideration of the conditions of statistical equilibrium of the electrons inside and outside different metals in contact, Richardson has shown that $(\partial/\partial T)[V_M - V_S] = P/T$, where $V_M - V_S$ is the contact p.d. between two metals M and S, P the Peltier p.d., and T the absolute temperature. The author describes experiments which he has made to test the above equation experimentally. For Fe and Bi, $P/T = 88{\cdot}7$ microvolts/degree, while for Fe and Ni it is 82·4. Earlier measurements of contact p.d. made by Erskine-Murray and by Burbidge are something like one hundred times too large to fit the above equation, and the measured values bear no obvious relation to the thermoelectric powers. Accurate measurements are difficult owing to the smallness of the effect in comparison with the superposed effects due to insulation charges, time changes, and oxidation. The experimental measurements thus far made have been by some form of the variable-condenser method. The author has used an ionisation method, in which the air between two plates is ionised by γ-rays and the potential of the plates so adjusted by a potentiometer that no current passes between them, the applied p.d. being then equal to the contact p.d. The latter can be measured accurately to 1/10,000 volt. The p.d.'s were measured several hours after effects due to polish, etc., had subsided. The mean value obtained for Fe-Ni over the range 20° to 60° C. was 1650 microvolts/degree, this mean being calculated from 5 values, the highest of which was 2160 and the lowest 1130. This result agrees fairly well with results obtained by the older method, and is about 50 times as large as the theoretical coefficient deduced from the above equation. It is clear that either the equation does not conform to the facts, or else what is actually measured is not the real contact p.d. The author considers the errors to be due to oxidation, and that consistent results are only to be obtained by the preparation of the surfaces and the measurement being carried out *in vacuo*. I. W.

606. *The Operation of Induction Coils with Electrolytic Interrupters.* **O. M. Corbino and G. C. Trabacchi.** (Elettrotecnica, 3. pp. 42–46, Jan. 25, 1916.)—The chief difficulty in feeding induction coils with alternating current and electrolytic interrupters consists in the strong inverse secondary current generated when the primary current is negative in direction. The authors have therefore devised an electrolytic interrupter which at the same time acts as a valve, so as to avoid the establishment of the negative primary current. The new electrolytic interrupter is formed of a Pt or Fe point, an Al plate, and a solution of a salt capable of producing the known valve action with Al. The best liquid is either a 20 % solution of sodium potassium tartrate or a saturated solution of sodium bicarbonate. This interrupter-valve does not require specially forming, but it forms itself in half a minute's working. The authors have compared the working of an induction coil fed by

direct current through an ordinary electrolytic interrupter and the working of the same coil fed by alternating current through the new valve interrupter. Several diagrams were taken by using the Braun tube. The d.c. feeding produces a considerable inverse e.m.f. that follows immediately on the direct secondary current and, finding therefore the X-ray tube in the excited condition, gives rise to an inverse current, which can be prevented only by the use of a secondary valve. The a.c. supply through the new valve-interrupter can, in favourable conditions, produce no inverse secondary current, so that no valve is required in the circuit of the tube. This is due to the fact that the inverse e.m.f. is smaller than in the former case, and is produced a long time after the direct current has ceased: the tube being no longer in the excited state does not allow the inverse current to pass. The favourable conditions for obtaining this result consist in giving a suitable value to the self-inductance of the primary and in letting the small electrode of the interrupter dip far enough in the liquid. As a matter of fact, what is called "direct current" is really in all cases a damped alternating current due to the self-induction and capacity of the secondary of the coil; but the inverse currents due to these rapid oscillations have no bad effect upon the X-ray tube. E. B.

607. *An Enclosed Cadmium-vapour Arc Lamp.* **H. J. S. Sand.** (Phys. Soc., Proc. 28. pp. 94–97; Disc., 97–98, Feb., 1916.)—The lamp is similar in general principle to the well-known mercury lamp. It is constructed of quartz glass. To start the lamp the metal is melted by means of a Bunsen burner, and the arc struck by tilting. Before introduction into the lamp the metal is freed from oxide and dissolved gases by a special process of filtration while at the pump. It is prevented from adhering to the glass, which might lead to fracture, by the presence of a small amount of a loose powder in the lamp. The lamp gives a powerful light, and once started will continue burning indefinitely. AUTHOR.

608. *New Form of very High Resistance.* **J. J. Dowling.** (Roy. Dublin Soc., Proc. 15. pp. 29–32, Feb., 1916.)—The resistance described is for use with electrometers. In measurements with these instruments a resistance of the order of 100 megohms is required. This resistance must not vary with the current, and it is desirable that it should be free from polarisation effects and possess no appreciable temperature-coefficient. Such a resistance is the equivalent resistance $R=1/nc$, where c is the capacity (in farads) of a condenser charged and discharged n times per sec. The author has tried such an apparatus with an equivalent resistance ranging from 10 to 5000 megohms in connection with electrometer measurements. The results are very favourable. F. E. S.

609. *Lecture-room Oscillograph.* **H. G. Crane and C. L. Dawes.** (El. World, 67. pp. 424–426, Feb. 19, 1916.)—An oscillograph is described by which it is rendered possible to project curves on to a screen that are readily seen at distances of 200 ft. or more from the screen. For flexibility in setting up the apparatus in different lecture-rooms the optical system, magnet and vibrators, and rotating mirror with its motor are mounted on three separate stands with means for adjusting height. The vibrator has a natural frequency adjustable between 1500 and 2000 cycles per sec., and with 200 milliamps. gives pictures with an amplitude of 12 in. on each side of the zero line with the instrument 10 ft. from the screen. With a special vibrator currents of telephonic frequency can be recorded. This vibrator gives an amplitude of

1 ft. with a current of 100 milliamps. and with the instrument set up 8 ft. from the screen. The rotating mirror has eight plane faces arranged so as to form an octagonal prism rotating at 75 r.p.m. with a supply at 60 cycles per sec.

A. J. M.

610. *Universal Switch for Thermo-element Work.* **W. P. White.** (Am. J. Sci. 41. pp. 307–316, April, 1916.)—Describes a switch used to simplify the manipulations required in making simultaneous measurements with different electrical instruments, especially thermo-elements or other sources of e.m.f. The contacts are made by pressure alone between strips of thin sheet copper, an arrangement which probably gives as small parasitic e.m.f.'s as any. The arrangement, shortly, is as follows: A straight wooden rod, when pressed in, presses against the "unknown" (say the thermo-element) contact, closing that. At the same time a pin, projecting sideways from the rod, pushes a frame which carries the auxiliary (usually the potentiometer) contacts. A turn of the rod makes the pin strike a different frame, giving a different auxiliary. The rod, when pushed in, is locked by an iron bar. It first raises the bar, releasing any other rod that may have been in. Hence, finally, to get a connection between any thermo-element and its auxiliary, it is only necessary to push the rod for that thermo-element, paying no attention to the auxiliary or to any previously connected thermo-element; and the auxiliary can be instantly changed for any thermo-element by rotating the rod between the thumb and finger.

J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

611. *Magnetic Properties of Electrolytic Iron deposited in Magnetic Fields.* **T. Sone.** (Tôhoku Univ., Sci. Reports, 4. 5. pp. 313–321, 1916.)—An experimental investigation of the magnetisation and hysteresis curves for specimens of iron obtained by electro-deposition in magnetic fields varying from zero up to 2600 c.g.s. In the weaker fields the deposition took place in the centre of a vertical magnetising coil; in the zero field, in a horizontal tube placed E. and W., and in the stronger fields the voltameter was placed between the poles of an electromagnet. The solution used in the weak fields was a mixture of ferric ammonium oxalate and ammonium oxalate, the anode being a Pt-wire and the kathode a copper tube. The solution was kept in continuous circulation and ammonia was added at a definite rate. An iron wire and copper tube formed the anode and kathode respectively in a solution of ferrous sulphate and ammonium chloride for the deposition in the strong fields. The measurements were made by the magnetometer method, and the results are represented in a series of curves. The chief conclusions to be drawn are:—(1) The curve of initial magnetisation of specimens obtained by deposition in a magnetic field lies considerably higher than that for specimens prepared in zero field. This is explained on the same grounds as the increase of magnetisation in ordinary iron by mechanical tapping. (2) The hysteresis curve for electrolytic iron is considerably wider than that for ordinary iron. The magnetic field applied during deposition does not sensibly affect the hysteresis curve, but the quantity of ammonia added has an influence. (3) The hysteresis curve becomes gradually flatter with lapse of time, and this flattening can be accelerated by annealing. L. L.

612. *The Hall-effect and Allied Phenomena in Tellurium.* **P. I. Wold.** (Phys. Rev. 7. pp. 169–193, Feb., 1916.)—An investigation of the galvano- and

thermo-magnetic properties of tellurium for field strengths up to 15,000 c.g.s. and the variation of these effects with temperature up to the melting-point of Te. The metal was in the form of a thin plate (4 cm. × 2 cm.) cast in a mould of asbestos slate under an atmosphere of hydrogen. The various leads and thermo-couples were fixed in position before pouring the molten metal. The plate was placed in the centre of a specially-constructed electric furnace, 15 cm. square by 2 cm. thick, and the whole fixed between the poles of a Weiss electromagnet. Potentiometer methods were used for measuring the resistances and e.m.f.'s; longitudinal temperature gradients were produced by a small heating coil placed at one end of the plate. Over the range investigated the author finds the Hall constant practically independent of the field strength. There is a disymmetry with reversal of field, but since this is proportional to the square of the field it is due to the Hall electrodes not being exactly on an equipotential. At ordinary temperatures the Hall constant is positive, but it diminishes rapidly with rise of temperature, changes sign, and with further rise of temperature reverses to positive again. The initial value depends on the heat-treatment, but there is always the double reversal as the temperature rises. It is only at ordinary temperatures that widely different values of the constant are obtained; at higher temperatures the curves for different heat treatments approach each other, and the reversal to the second positive value occurs at 245° C. This behaviour cannot be regarded as due to impurities, special precautions having been taken in preparation of the specimen, and analysis showed the amount of oxide present to be exceedingly small. The author considers it due to the existence of two crystalline forms, α and β. According to Haken, the α modification is stable below 354° C. and the β form above this temperature. The author assumes a positive Hall constant for the β modification and a negative for the α. As the Te is cooled the β form passes into the α form, but the quantity making the transition will vary. A curve connecting thermoelectric power and temperature has a shape similar to that for Hall constant and temperature.

Attempts were also made to measure the Hall constant in liquid Te, but the results were unsatisfactory. Except in gases the Hall-effect has not been observed in amorphous substances. A Te plate was prepared by pressing the finely precipitated metal. The Hall constant was small, but a microphotograph shows considerable crystalline structure. The author suggests that a crystalline structure is essential for the Hall-effect. The change of resistance in the magnetic field was found proportional to the square of the field strength. The resistance of Te was very variable at ordinary temperatures, depending on the previous heat-treatment, but diminished with rise of temperature and in all cases approximated to the same value at 150° C. The increment in resistance in the magnetic field was greater at the lower temperatures, the curve connecting change of resistance and temperature being very similar to that for resistance and temperature. The Ettingshausen-effect was found to be proportional to the field strength and to increase with rise of temperature. The Nernst-effect was also approximately proportional to the field, but diminished in value with increase of mean temperature of the plate. The Leduc-effect was proportional to the field strength. A diminution of about 19 % in the thermal conductivity was observed in a field of 6500 c.g.s., the mean temperature of the plate being 45·8° C. L. L.

613. *Damping of Torsional Vibrations in Nickel Wire in a Variable Magnetic Field.* **E. Drago.** (N. Cimento, 10. pp. 448–457, Nov.–Dec., 1915.)—The nickel wire is loaded and the damping of the torsional vibrations observed while the magnetic field, which is longitudinal, is produced by a vertical solenoid. In the first experiment an annealed nickel wire was used, the magnetic field of 178 gauss being reversed at each simple oscillation. The amplitude falls from 889 to 45 in 20 simple oscillations, while in the earth's field only it falls from 889 to 852 in the same number of oscillations. With iron instead of nickel the fall is 890 to 280. With the nickel wire and an alternating current of periodicity 46 a maximum of damping occurs with a magnetic field of 48 gauss, being 400 to 816 in 40 simple oscillations. Oscillatory magnetic fields were also used, a decrease of damping (from 400 to 808 in 80 simple oscillations) occurring with a capacity of 27×10^{-4} mfd. to lower values when greater capacities are used. The length of spark-gap employed also affects the damping. [See also Abs. 1027 (1914).] S. G. S.

614. *Diurnal Magnetic Inequalities at Kew from* 1890–1900. **C. Chree.** (Roy. Soc., Phil. Trans. 216. pp. 187–277, March 28, 1916.)—The paper gives a most detailed discussion of the Kew magnetic data from records on ordinary days of the eleven years 1890–1900, and any attempt at summarising would be of slight value. The diurnal inequalities are presented as tables giving the figures for each hour of the day; also as comparison curves for individual months, seasons, and sun-spot epochs; and again as the instructive vector diagrams used by the author in previous investigations. With regard to the possibility of extra-terrestrial influence, it is stated that in the case of the mean diurnal inequality for the year, there is a close connection between the range and the corresponding sun-spot frequency. This does not necessarily imply any close connection between sun-spot frequency on any given day and the amplitude of the regular or irregular magnetic changes on the same day, and it is considered difficult to think of any cause for the magnetic diurnal inequality other than electrical currents in the upper atmosphere. In temperate latitudes, whether at maximum or minimum, regular magnetic changes are most rapid during the day, but the difference between day and night seems reduced to sun-spot maximum. Whether by day or by night, the regular changes are larger in sun-spot maximum than in sun-spot minimum. The most natural inference is that direct sunlight, whether there are or are not sun-spots, increases the conductivity of the upper atmosphere, and the effect persists to some extent during the night. C. P. B.

615. *A Portable Variometer for Magnetic Surveying.* **G. W. Walker.** (Roy. Soc., Proc. 92. pp. 318–321, March 1, 1916.)—The usual method of measuring the horizontal component of the earth's magnetic force is due to Gauss, and consists essentially of a vibration experiment and a deflection experiment. The whole operation cannot be completed in much under an hour. The author states that the average error in readings obtained by this method is not likely to be less than 5γ, *i.e.* 5 parts in 18,500, where the instrument is installed in a fixed observatory, and not less than three times this value under the conditions prevailing in a magnetic survey. The variometer described in the paper is particularly suitable for this latter work, where it is rather the differences in the force at different places which are primarily to be measured than the actual values of the force. The apparatus consists of a small magnet suspended horizontally by a quartz fibre, the top of which may be twisted by means of a suspension head until the magnet takes up a position nearly at right angles to the magnetic meridian at the time. A telescope is fixed to the framework of the instrument for reading the position taken up by the magnet. When thus

suspended the angular movement of the magnet relative to the torsion head is proportional to the change of horizontal force, after application of a temperature correction. The readings are uninfluenced by small changes of declination. So long as the adjustment of the torsion head is not changed the readings of the horizontal force may be directly obtained from the readings of the angular position of the magnet. Further, the instrument may be moved from place to place, and provided that it is set up in approximately the same position with reference to the magnetic meridian, relative values of the horizontal force at the different places will be given. A portable instrument was made on these lines, and fitted with means for clamping the magnet in position to prevent damage during transit. At the time of devising this instrument the author was engaged on a magnetic survey of the United Kingdom, and for this purpose was using a Kew pattern unifilar. The new variometer was therefore designed to fit directly on to the Kew instrument, so that the same relative position of variometer, unifilar and magnetic meridian was always obtained. In the course of a survey of Ireland, readings were taken at each station by means of both the new and old methods, and the comparative results are set out in the paper. A slow secular change of 1γ per day was found in the zero of the variometer, due probably to a gradual fall in the moment of the magnet, which was comparatively new. This change was allowed for. The author considers that the investigation supports the view that the variometer will normally give the force within 5γ, while the unifilar in the field will normally give it within 15γ only. On the other hand, with the variometer access is required at intervals during a survey to a properly equipped observatory where the instrument may be standardised. There can be no question of the enormous simplification of the field work which such a portable variometer produces, it being possible to obtain a reading of the horizontal force by its means within 10 minutes of setting up the instrument in its correct position relative to the meridian. Readings can also be taken at night. J. S. Di.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

616. *Radiography of Metals.* **W. P. Davey.** (Am. Electrochem. Soc., Trans. 28. pp. 407–418, 1915.)—The results of the examination of a steel casting [Abs. 172B (1915)] were so promising that it appeared desirable to study the general technique of the radiography of metals. Formulæ have been worked out for the calculation of the exposure required for steel plates of various thicknesses, using 15-in., 18-in., and 11-in. spark-gaps. While the effective penetration at a 18-in gap is greater than at an 11-in. gap, no greater penetration is obtained by the use of a 15-in. gap, but there is a marked decrease in the exposure required consequent upon the increase in the voltage across the tube. At present it is impracticable to radiograph through more than 1¼ in. of steel, and, commercially, radiography is only possible up to a thickness of ½ in. The saving of time gained by the use of a 15-in. spark-gap as against a 18-in. gap, however, points to the fact that a further increase of the voltage across the tube would make the radiographing of still greater thicknesses of steel a commercial possibility. Published data on the scattering of X-rays in Al lead to the expectation that the use of high voltages would result on the production of blurred images, but this does not appear to be the case. Experiments show that by the use of a 15-in. spark-gap it is possible to detect an air inclusion 0·021 in. thick in 1¼ in. of steel, and an air inclusion 0·007 in. thick in ⅜ in. of steel. F. C. A. H. L.

617. *A Marking Apparatus for Localising Projectiles in the Wounded.* **Le Marechal and Morin.** (Comptes Rendus, 162. pp. 282–283, Feb. 7, 1916.)—This instrument enables the normal to the table passing through the foreign body, together with the distance of that body from the table, to be found easily and exactly. At the same time it enables the necessary cutaneous points to be marked with the greatest exactitude. The part E is a horizontal fluorescent screen. When the pointer t_1 is at the level of the projectile and points towards it, the shadows on the glass screen of the point t_1 and of the projectile are in the same line, and for all transverse displacements of the bulb they are displaced equally: consequently under these circumstances they always remain in the same line. For any other level of t_1 the displacements are unequal. This affords a means of regulating the height of t_1. t_2 is next placed perpendicular to t_1, and the arc, shown in Fig. 2, brought into the vertical plane. The instrument is then arranged near the patient, so that t_2 is in the vertical with the projectile, and is made to touch the skin at R_1. The projectile is then at the meeting of t_1 and t_2 produced, and consequently at the centre of the spherical surface which the arc describes in its movement. A mark R_2 in the direction of t_1 is placed upon the skin. Lastly, a third mark R_3 is chosen arbitrarily, and t_4 is brought in touch with it. The position of the nut N with respect to the supporting column is noted, and also the free lengths of the pointers t_1, t_2, and t_4. With these data it is always easy to arrange the apparatus in an identical position with respect to the patient, and for the surgeon readily to locate the projectile. A. E. G.

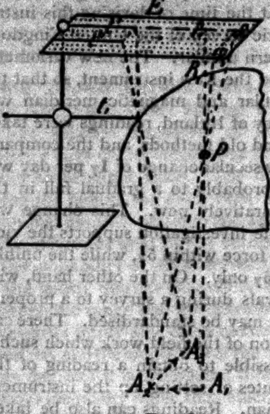


FIG. 1.

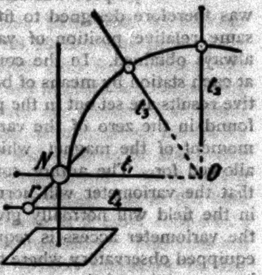


FIG. 2.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

618. *High-temperature Investigations.* V. *Manganese and Carbon.* **O. Ruff and W. Bormann.** (Zeits. Anorg. Chem. 88. pp. 365–385, Sept. 15, 1914.)—The experiments were made in a vertical, tubular electric vacuum-furnace in which the graphite or zirconia crucible is so mounted within a tube (sliding within the furnace tube) that the crucible can quickly be dropped for quenching. Temperatures below 1500° are measured by thermo-couples, above 1500° by a Wanner pyrometer. From 20 to 40 gm. of carbon and the respective metal are generally fused together. In order to secure constant temperature the crucible is very slowly heated up. Boiling-points are directly observed, the quiet seething following incipient spitting being taken as the proper moment. The vapours could not be analysed, and their composition is found by determining the volatilisation losses of metal and of carbon ; in such tests the crucible is covered with two perforated discs to prevent loss by spitting. Since the vapour pressure of graphite must be very small, even at 3000°, it is assumed that the carbon percentage in the vapour indicates the presence of a corresponding amount of carbide. The furnace arrangements were practically the same for all the papers of this series. The manganese-carbon diagram had last been investigated by Stadeler in 1908, and the authors supplement his work. Their manganese was of 98·68 % (with some Fe and Al, 0·25 % of insoluble residue and 0·02 % C). The carbon percentage in the fused mass increases as the temperature rises ; at 1260° the composition of the fused mass corresponds exactly to Mn_3C ; the solubility of carbon as such in the metal is very small, since there was never any residue of carbon when the regulus was quenched and dissolved in hydrochloric acid. At 1525° the solution boils under 30 mm. pressure ; it then contains 7·12 % C ; the vapour contains 1·94 % C. The high percentage of C in the solution (7·12) is surprising, because the dissociation of the carbide in the solution can only be very small, considering the fact mentioned that no free carbon is found. When the solution boils, vapour and solid graphite remain behind. As regards the nature of the carbide probably present in the vapour, nothing can be said ; but there may be higher carbides than Mn_3C. Pure Mn boils at 1500° under 30 mm. pressure. H. B.

619. *High-temperature Investigations.* VI. *Nickel and Carbon.* **O. Ruff and W. Bormann.** (Zeits. Anorg. Chem. 88. pp. 386–396, Sept. 15, 1914.)—In 1912 Ruff and W. Martin investigated the solubility of graphite in Ni above 1560° ; their curve did not agree with the curve of Friedrich and Leroux as to lower temperatures, but was confirmed by Ruff and Gersten. The present research again particularly refers to Friedrich and Leroux, and gives the whole Ni-C diagram. The eutectic point is 1311° at 2·2 % C (Fr-L : 1308–1310°, 2 to 2·5 %) ; about 0·55 % C is held in solid solution. The solubility of C increases as the temperature rises to 2100° (6·4 % C) and decreases afterwards ; the composition is then Ni_3C ; at 2490° the mass boils at 30 mm., the carbon-content then is 6·8%, and the solution is decomposed into graphite and a vapour containing 0·28 % C, probably as carbide. Nickel itself melts at about 2400° under 30 mm. pressure. H. B.

620. *High-temperature Investigations.* VII. *Iron and Carbon.* **O. Ruff and W. Bormann.** (Zeits. Anorg. Chem. 88. pp. 397–409, Sept. 15, 1914.)—The diagram had previously been investigated by Ruff and Goecke, and the work was repeated to meet the criticisms of Wittorf and of Hanemann; the results are a confirmation of the authors' previous work. Iron saturated with 7·54 % C boils at 2650 ± 25°; this point is more reliable than the melting-point of pure iron, which seems to be 2450 ± 50°, at 30 mm. pressure. The vapour from the first-mentioned saturated solution contained only 0·91 % C; this surprisingly low percentage would explain why iron does not take up much carbon in steel furnaces when an arc is formed between the carbon electrode and the molten iron. H. B.

621. *High-temperature Investigations.* VIII. *Cobalt and Carbon.* **O. Ruff and F. Keilig.** (Zeits. Anorg. Chem. 88. pp. 410–423, Sept. 15, 1914. F. Keilig's Dissertation, Danzig.)—The diagram had previously been investigated by Bœcker (1912), from whom the authors differ in several respects. Their cobalt was of 99·35 %, containing, in addition, Ni, Fe, Si, and a trace of Cu. The solubility of carbon in liquid Co is 2·4 % at the eutectic point, and increases up to 7·3 % at 2415°. Above that temperature it is all vapour and solid graphite, and the vapour contains 2 % (possibly 2·6) C, which is extraordinarily high. The boiling-point of pure Co seemed to be 2375°, but may be higher. An inflection in the curve corresponds to the carbide Co_3C; but this carbide decomposes rapidly, and cannot even be isolated by quenching. H. B.

622. *Physico-chemical Studies of Antimony.* **E. Cohen and J. C. van den Bosch.** (Zeits. Phys. Chem. 89. pp. 757–760, May 26, 1915.)—The authors had so far distinguished four allotropic forms of antimony: (*a*) metallic, bluish-white, metallic lustre, occurs in nature, crystallises in the hexagonal system; (*b*) black, most easily obtained by condensing vapour of Sb; passes slowly at 100°, rapidly at 400°, into (*a*); (*c*) yellow, from the hydrogen compound at −90°, passes into (*b c*); (*d*) explosive. Fusing over 1 kg. of very pure Sb (only a few hundredths of 1 % impurities) and pouring the metal into a paper cylinder surrounded by a freezing mixture of solid CO_2 and alcohol, they obtain a metal of density D^{25}_{4} 6·6899, which, finely powdered and heated to 102·5° for several hours, passes into a metal of density 6·6786 within the same temperature limits. By dilatometer observations the transformation-point is fixed at 101°. They hence conclude that the ordinary metallic antimony (*a*) is a metastable system containing sometimes more than two modifications, and that all the constants ascribed to Sb are more or less accidental. H. B.

623. *Boron Steels.* **G. Hannesen.** (Zeits. Anorg. Chem. 89. pp. 257–278, Nov. 5, 1914.)—Goldschmidt's ferro-boron (78·02 % Fe, 21·03 B, 0·96 Al) is fused in a hydrogen atmosphere (not very suitable above 1200°, but nitrogen is out of the question) with a Krupp steel (0·07 % C, 0·09 Si, 0·08 Mn), and about 20 gm. of alloy is examined in each case. The boron steels resemble carbon steels thermally and structurally, but have their peculiarities; there is, *e.g.*, no boron-austenite. The series is studied up to 8·5 % B; in the presence of more than 4 % B a grey powder was formed by heating to about 1500° for 10 mins., which caused difficulties; the composition of this powder is not yet known. The maximum of the freezing-point curve at 1351° corresponds to the richest boron alloy formed, Fe_2B, which occurs in all

solutions, from 0·25 up to 0·5 % B; its rhombic crystals are generally elongated to needles. The transformation temperatures of the original iron were: γ — β 895°, β — α 800°; these temperatures were lowered by the addition of boron, the curves for different small boron percentages being all fairly parallel to one another. There is an arrest in the curves of all the solutions at 718°, corresponding to the liberation of Fe_3B_2. This boride itself and all the alloys are ferro-magnetic. There is a boron-pearlite; if the metal is quenched at 1100° in water and etched with alcoholic picric acid, however, pearlite is no longer found, and the steels are less hard than those containing the pearlite. By etching the quenched steel with 4 % nitric acid and isoamylalcohol low-boron steels (up to 0·25 % B) are shown to consist of very small grains; in the presence of more boron the structure is martensitic, but there is no boron austenite, perhaps because γ iron dissolves much less boron than carbon. The hardness rises in slowly-cooled specimens with the boron percentage, from 5 or 6 on the Mohs scale to 8 and 9, corundum being attacked by steels with 0·5 % B. H. B.

624. *Microscopical Changes accompanying the Annealing of Cast Bronze.* **H. S. Rawdon.** (Bureau of Standards, Technol. Papers No. 60. [17 pp.], Washington, 1916.)—This paper deals with the effect of annealing on bronze consisting of Cu 88, Sn 10, Zn 2. The dendritic structure is found to persist until the specimens have been heated for approximately 2 hours at 800°. In samples which solidified very slowly, 4 hours' heating at 800° is required for the absorption of the eutectoid; this is longer than the time required in the case of specimens solidified more rapidly, and is probably due to the larger size of the eutectoid inclusions in the former case.

No evidence is obtained suggesting a change of crystal size of cast samples which have not been distorted previous to annealing.

Recrystallisation, including "twinning," is found only to follow distortion or its equivalent; metal cooled suddenly from the molten state behaves similarly because of the high internal stresses resulting. The progress of recrystallisation on annealing for different periods of time at the same temperature is in agreement with Tammann's theory which implies that for any given temperature the final crystal size is a determined one.

Apart from crystal size and shape, and twinning, the condition of the material annealed after casting and the same material annealed after a preliminary distortion, is the same. C. O. B.

625. *New Thermoelectric Method for the Study of the Allotropy of Metals.* **C. Benedicks.** (Comptes Rendus, 162. pp. 297-299, Feb. 21, 1916.)—In a closed circuit made up of a homogeneous metal, no e.m.f. results on changing the temperature of any portion of the circuit. Even if the metal does possess an allotropic change-point, no e.m.f. is produced if the heating be stationary, because the potentials of the two phases balance each other. If, however, the heating is not stationary, the contact surfaces of the two phases may acquire different temperatures, when an e.m.f. will be developed. This principle has been applied to the study of the allotropy of iron by causing wires, containing 0·10 % carbon and only very small amounts of other impurities, to traverse a small electric furnace, the central temperature of which was measured by means of a thermo-couple. Deflection-temperature curves show that no effect is produced at temperatures below 600° C. Between 600° and 875° the effect is slight but continuous, while at 875° there is a marked discontinuity in the curve indicating the A3 point. A more detailed investigation of the range between 700° and 800° shows that there is no discontinuity to indicate the position of A2. A sample of pure electrolytic iron gave similar qualitative results. The author considers that the results confirm his theory as to the non-existence of A2 as an allotropic change-point in iron. F. C. A. H. L.

626. *Copper-Nickel and Cobalt Alloys.* **M. Waehlert.** (Oesterr. Zeits. f. Berg-u. Hüttenwesen, 62. pp. 341–346, 357–361, 374–378, 392–395, 406–410, 1914. Chem. Zentralblatt, II. pp. 919–920, 1914.)—The thermal, magnetometric and mechanical investigation concerns binary alloys, including Monel metal (1Cu + 4Ni), and the ternary system Ni-Cu-Co. The materials were electrolytic Cu and electrolytic Ni; the Co was reduced by means of hydrogen from its protoxide; the alloys were fused in carbon tubes heated in Friedrich porcelain gas-furnaces, under protective salt layers. A platinum furnace was built into the magnetometer, of which a detailed description is given. As regards Ni-Co and Cu-Co, the author agrees in the main with Ruer and Kaneko and with Sahmen respectively. No new phenomena were discovered in the ternary alloys. To secure great hardness in copper alloys, Co and Ni should be added in equal proportions. All the alloys are attacked by nitric acid, but resist sulphuric acid; the addition of Co favours corrosion. Monel metal is found to be the most acid-proof of the alloys examined. H. B.

627. *Freezing-point Solubility Law for Ideal Solutions.* **E. W. Washburn** and **J. W. Read.** (Nat. Acad. Sci., Proc. pp. 191–195, April, 1915.)—Two completely miscible, pure liquids may dissolve in one another without appreciable heat effect or change of volume, if the two constituents resemble each other very closely; such solutions are called "ideal." The vapour pressure p_A of the constituent A in such a solution is proportional to the mole-fraction x of that constituent in the solution, or $dp_A = kdx_A$. From this equation the other laws of ideal solutions can be deduced thermodynamically, and the freezing-point solubility relation was chosen to test the accuracy of the laws of ideal solutions. For the two substances A and B the increase in the mole-fraction is given by $d\mathrm{T}/dx_A = \mathrm{RT}^2/\mathrm{L}_A x_A$, and similarly for B, where T is the absolute temperature of the freezing-point and L the molecular heat of fusion. The L values for benzene, diphenyl, naphthalene are 2370, 4020, 4560 cals., the melting-points 5·48°, 68·95°, 80·09° in the same order. The eutectic points found (and calculated) by the authors are: benzene-naphthalene −3·48 (−3·56)°; benzene-diphenyl −5·8 (−6·1)°; naphthalene-diphenyl +39·4 (39·4)°; these determinations were made by an equilibrium method, the assumption being that L is independent of T for the range involved, which is questionable for diphenyl. The agreement is close, however, and the solutions may be considered ideal. Under two conditions the freezing-point or solubility of a solid in a liquid may hence be calculated: (1) the heat of solution must be zero for the range involved, (2) the dilution of the solution must not involve any chemical change. It then follows that when a crystalline substance A forms an ideal solution with B the mole-fraction is entirely independent of the nature of the solvent B and therefore the same for all solvents, depending merely upon the melting-point of A, its heat of fusion, and temperature. This rule was discovered by Schröder (Zeits. Phys. Chem. 11. p. 49, 1893), but has not received attention. The considerations further furnish a ready method for detecting the presence of racemates in the liquid state. H. B.

628. *Ice Crystallisations from Aqueous Solutions.* **R. Hartmann.** (Zeits. Anorg. Chem. 88. pp. 128–182, Aug. 6, 1914.)—The solutions contain cane sugar, glycerol, alcohol, NaBr, $MnSO_4$, NaOH, $FeCl_3$, or HCl, etc., in water, and are undercooled, with the two last-mentioned solvents, to —38 and 40° C. The crystallites then separating are of four or five types: (*a*) the skeletons or nuclei are hexagonal or rectangular in outline, but the three or two (rectangle) axes cross in both cases at 60°; (*b*) and (*c*) spherulites, radial or built up of plates; (*d*) feathery growths. With moderate undercooling (*a*) is obtained; (*b*) and (*c*) with heavy undercooling; (*d*) in very dilute solutions, whatever the cooling. In order to see whether the nuclei have all the same melting-points, they were placed in water at —2° and then very slowly heated up, differences of 0·001 deg. C. being observable; the melting-points were always found normal. In the case of the two (*a*) types, the linear velocity of crystallisation was further determined; no differences were observed. When, in the spontaneous crystallisation, a nucleus happens to settle on the glass surface with its base, a hexagon seems to be formed; when with its rectangular edge, a rectangle is formed. H. B.

629. *Solutions of Metals in Boiling Mercury.* **E. Beckmann** and **O. Liesche.** (Zeits. Anorg. Chem. 89. pp. 171–190, Oct. 20, 1914.)—The apparatus for ebullioscopic experiments is made of Jena borosilicate glass 19^{III} and takes 200 gm. of mercury which is well stirred to avoid the bumping of the boiling metal; an atmosphere of CO_2, and a tin bath (395° C.) are used. The results of such experiments have sometimes been interpreted as giving abnormally high or low molecular weights; the authors refer them to the ebullioscopic constant, stating the elevation of the boiling-point produced by dissolving 1 gm.-atom of a metal in a solvent. When the constant turns out too high, an addition of solvent to the solute is assumed; this addition is much more important in the case of mercury than with other solvents, because the atomic weight of mercury is high, 200, and the amalgams are very rich in mercury. The valne 114 is accepted for the ebullioscopic constant of mercury. Experiments were made with a large number of metals of different groups. The metals of the alkalies and alkaline-earths as well as thallium yield too high a constant, so that the amalgam seems to be associated with mercury, the formulæ being apparently: $NaHg_7$ or $NaHg_8$, KHg_{11} or KHg_{14}, $CaHg_{16}$. The metals Cd, Zn, Ag, Au seem to give monatomic solutions, without association; Sn, Pb, Bi incline to association. H. B.

630. *Lowering of the Vapour Pressure of Water produced by Dissolved Potassium Chloride.* **B. F. Lovelace, J. C. W. Frazer,** and **E. Miller.** (Am. Chem. Soc., J. 38. pp. 515–528, March, 1916.)—The authors have previously described a static method [see Abs. 471 (1915)] for the study of the vapour tension of aqueous solutions, and the present paper contains a detailed record of certain alterations made to improve its efficiency. They now claim their apparatus to be capable of giving the vapour tension depressions of aqueous solutions correctly to 0·001 mm. or less. The principal changes made are: (1) The alterations of the thermostat and thermo-regulator designed to secure a more nearly constant temperature, and (2) the introduction of a method for the continuous stirring of the solvent and solutions while in a vacuum. The temperature of the thermostat can be maintained constant to 0·001 deg. for periods of 12 hours or more. After the absorption of the water-vapour a more sensitive McLeod gauge has been introduced for measuring the residual air-pressure, and actual observations of the vapour-pressure lowering are only made after this gauge registers less than 0·0001 mm. Under these conditions the vapour-pressure lowering of a given solution remains constant for days to 0·001 mm. Solutions of potassium chloride varying in concentration from 0·2 M to 2·0 M have been studied. It has been shown by the analysis of the solutions from the apparatus after the measurements have been made, that the change of concentration of the solutions during the process of removing the dissolved air and measuring the vapour-tension lowerings is small enough to be neglected. The most striking feature of the experimental results is, that for all concentrations investigated, the molecular lowering of vapour tension is the same. Similar results have been obtained by Tower and Germann from a study of the vapour tension of alcoholic solutions of potassium bromide and lithium chloride. Whether this phenomenon can be explained by the combination of the solvent and solute, as suggested by Tower and Germann, cannot be decided until the rigid applicability of Raoult's law has been tested with some non-electrolyte over the same range of concentration. This the authors purpose doing.

Tables and illustrations are given. H. H. Ho.

681. *Stability and Oxidation Potential of Hypochlorites. Catalysis and a Hypochlorite-Carbon Cell.* **K. A. Hofmann** and **K. Ritter.** (Deutsch. Chem. Gesell., Ber. 47. pp. 2233–2244, July, 1914.)—Pure calcium hypochlorite, free from calcium chloride, having become obtainable from the Griesheim-Elektron Works, the authors investigated its behaviour on heating up to 90° and in the presence of CO_2 and also of catalysts, comparing it with the behaviour of other hypochlorites (Na, K) and of chloride of lime (bleaching powder). In dry air free from CO_2 there is no difference between the Ca-hypochlorite and bleach, and very little evolution of chlorine even at 90°; in moist air the bleaching powder loses more chlorine; in a current of moist CO_2 they both (and mixtures of the calcium hypochlorite and chloride as well) lose all their active chlorine. As regards available oxygen, bleach will hardly contain more than 0·027 gm./cm³., whilst the pure calcium hypochlorite contains 0·058 gm. With respect to catalysts which are added to increase the oxidising power of hypochlorites, hydrogen peroxide, etc., it is necessary to distinguish between (*a*) oxygen-liberating catalysts (powdered iridium, cobaltic oxide), and (*b*) oxygen-carriers (osmium tetroxide); (*a*) catalysts cannot promote oxidation, because they remain themselves unchanged, and when Ir is added to mixtures of organic compounds and hydrogen peroxide, oxygen gas is liberated (not *in statu nascendi—i.e.* not in atomic form, as is often assumed), but the oxidation is not promoted. Hence (*a*) catalysts do not affect the e.m.f. either. In determining the oxidation-potentials of hypochlorites (mixed with the hydroxide of calcium or with soda), unattackable electrodes had to be found; as such answer, Pt, Au, magnetite, and (in absence of CO_2) also Cd, Fe, Sb, Ag; graphite and lampblack are attacked. The potential of the calcium hypochlorite against the calomel electrode is $\epsilon_c = 0{\cdot}608$ volt, against the hydrogen electrode $\epsilon_h = 0{\cdot}988$; bleaching powder gave nearly the same but unstable values; the alkalinity affects the potential, dilution but little. A fairly satisfactory galvanic cell was built up of: Pt in alkaline hypochlorite | $CaCl_2$ of 20 % | iron in 20 % $FeCl_2$; this gave 1·82 volts, but only 38 % of the available oxygen was utilised for current generation. By replacing the iron by zinc in $ZnCl_2$, the values were raised to 1·71 volts, and 68 %. The combination: Pt in sodium hypochlorite and carbonate | 20 % NaCl | 10 % caustic soda and zinc

oxide and zinc gave 2·24 volts and a yield of 92 %. Experiments were then made with carbon (charcoal from beechwood, etc., or sugar). Electrodes containing this charcoal within the meshes of Pt-wire gauze gave + 0·12 volt against hydrogen electrode in 2N-NaOH, and + 0·7 volt in 1N-HCl; but the hypochlorite solutions had to be alkaline. Hence the combination: Pt in sodium hypochlorite and soda | 2N-NaOH | beechwood electrode in 2N-NaOH; this gave 0·76 to 0·91 volt, and, when coupled with a silver voltameter, a current yield of 76 %; the oxygen was almost entirely spent in oxidising the carbon to CO_2. Such cells might answer; but experiments are being made to utilise oxygen directly instead of using the rather expensive hypochlorite; bleach solutions are too unstable. H. B.

632. *The Hypochlorite Carbon Cell; New Type of Galvanic Element.* **A. Thiel.** (Zeits. Elektrochem. 21. pp. 325–329, July 1, 1915.)—In the course of an investigation of hypochlorites, their stability, oxidising power, potential and behaviour under catalysis, K. A. Hofmann and K. Ritter [see preceding Abs.] built up various couples depending upon the ordinary powers of hypochlorites. Carbon does not emit ions, neither does it absorb them. The new cell does not belong to the type of Jacques' so-called carbon cell, which was really an oxy-hydrogen couple. The Smee cell (amalgamated zinc, sulphuric acid, and Pt) is probably an analogous case when provided with a depolariser (the chromic acid of the Grove cell). In the new cell, the negative electrode is depolarised by the charcoal, so that CO_2, not O, is liberated at the electrode and absorbed by the caustic soda. The energy is the same as that of the oxidation of the carbon, yet there is no real equilibrium, the rate of depolarisation being the main factor. The carbon acts as depolariser, not electrochemically, but merely chemically, and in so far the cell constitutes a new type. As molecular oxygen is inert, it will be difficult to utilise atmospheric oxygen in the cell. H. B.

633. *Factors affecting the E.M.F. of Binary Solid Alloys.* **D. P. Smith and N. T. Gordon.** (J. Phys. Chem. 20. pp. 228–242, March, 1916.)—Preliminary experiments have been made with brass with the object of determining the factors affecting the potential of a solid binary alloy. Chief among these factors are (*a*) heat treatment and surface treatment, and (*b*) composition of the electrolyte against which the e.m.f. is measured. The electrolyte was kept as still as possible, the flow of nitrogen through the apparatus being suspended prior to the commencement of the observations. The brass was prepared by fusing together "Kahlbaum" zinc and copper under borax, eight horizontal layers which were cut exhibiting a regular variation in composition from 50·67 % Cu at the top to 49·54 % at the bottom. It is found that a highly uniform, well-annealed brass, the surface of which is subjected to no mechanical treatment from one experiment to the next, may give a potential reproducible to within a few millivolts, in spite of slight differences in the Cu-content of the electrolyte. This result indicates that changes in the composition of the electrode surface play a greater part than do changes in the composition of the electrolyte in the attainment of equilibrium between the two. Besides emphasising the necessity of employing the equilibrium electrolyte, if the potential of a surface of known composition is to be ascertained with accuracy, the results furnish evidence of the great uniformity of the alloy, since in each instance the values show a very gradual, steady "drift," the sense of which is determined by the composition of the electrolyte, instead of the highly irregular rise and fall of several centivolts or even decivolts observed, for example, by

Broniewski [Abs. Nos. 518, 544 (1911)] with Al alloys prepared without special care to secure uniformity. Surface treatment produces a marked influence, giving rise to "drifts," the direction of which cannot be foreseen. T. H. P.

634. *E.M.F. and Change of Inner State of the Daniell Cell.* **Z. Samesima.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 370–381, Feb., 1916.)—After a short historical introduction the author gives details of the experiments he has carried out on the e.m.f. of a Daniell cell, as influenced by various factors. Using twice-normal solutions of copper sulphate and zinc sulphate, it is found that cells built up with and without porous pots as diaphragm give the same e.m.f. to two places of decimals; the cells with porous pots give a slightly higher e.m.f. in the third decimal place. A bright copper electrode gives a higher e.m.f. than an electro-deposited one, possibly because of strain existing in its inner structure. Details are also given of the e.m.f.'s of cells constructed with ordinary commercially-pure materials.

The influence of time on the e.m.f.'s of a number of cells was also investigated. All the cells were kept on open circuit, save when the measurements were made, except one cell which was kept closed through a resistance of 10,000 ohms; the electrolytes used were twice-normal solutions, and one cell was kept under diminished pressure in order to remove any gas formed at the electrodes. No noticeable difference in e.m.f. was found whether the cell was kept on open or closed circuit, and the gas evolved at the zinc electrode had very little effect. The e.m.f. of a cell: amalgamated Zn | 2N — $ZnSO_4$ | bright Cu, was about the same as that of a Daniell cell, and remarkably constant with time. In some cases it was noticed that after 3 or 4 days copper deposited itself on the outer surface of the porous pot. Special experiments gave the following explanation: The zinc electrode gradually becomes covered with spongy Cu, owing to the diffusion of copper sulphate through the porous pot. The quantity of spongy copper gradually increases until it reaches the walls of the pot, through the pores of which the growth of copper gradually makes its way. On reaching the outer side of the pot, the growth continues and becomes self-evident. T. S. P.

635. *Use of Hydrofluoric Acid in Separation of some Heavy Metals from Tin, Antimony, Tungsten, and Molybdenum by means of Electric Current.* **Le R. W. McCay** and **N. H. Furman.** (Am. Chem. Soc., J. 38. pp. 640–652, March, 1916.)—Using the nitrohydrofluoric acid electrolyte previously described [see Abs. 230 (1915)], the authors give the experimental details necessary for carrying out successfully the following separations: Ag from Sn and Sb; Hg from Sn and Sb; Cu from W; Cu from Mo; Cu from W and Mo; Pb from W; Pb from Mo; Pb from W and Mo; Hg from W; Hg from Mo; Hg from Sn, Sb, W, and Mo; Ag from Sn, Sb, W, and Mo; and Cu from Sn, Sb, W, and Mo. T. S. P.